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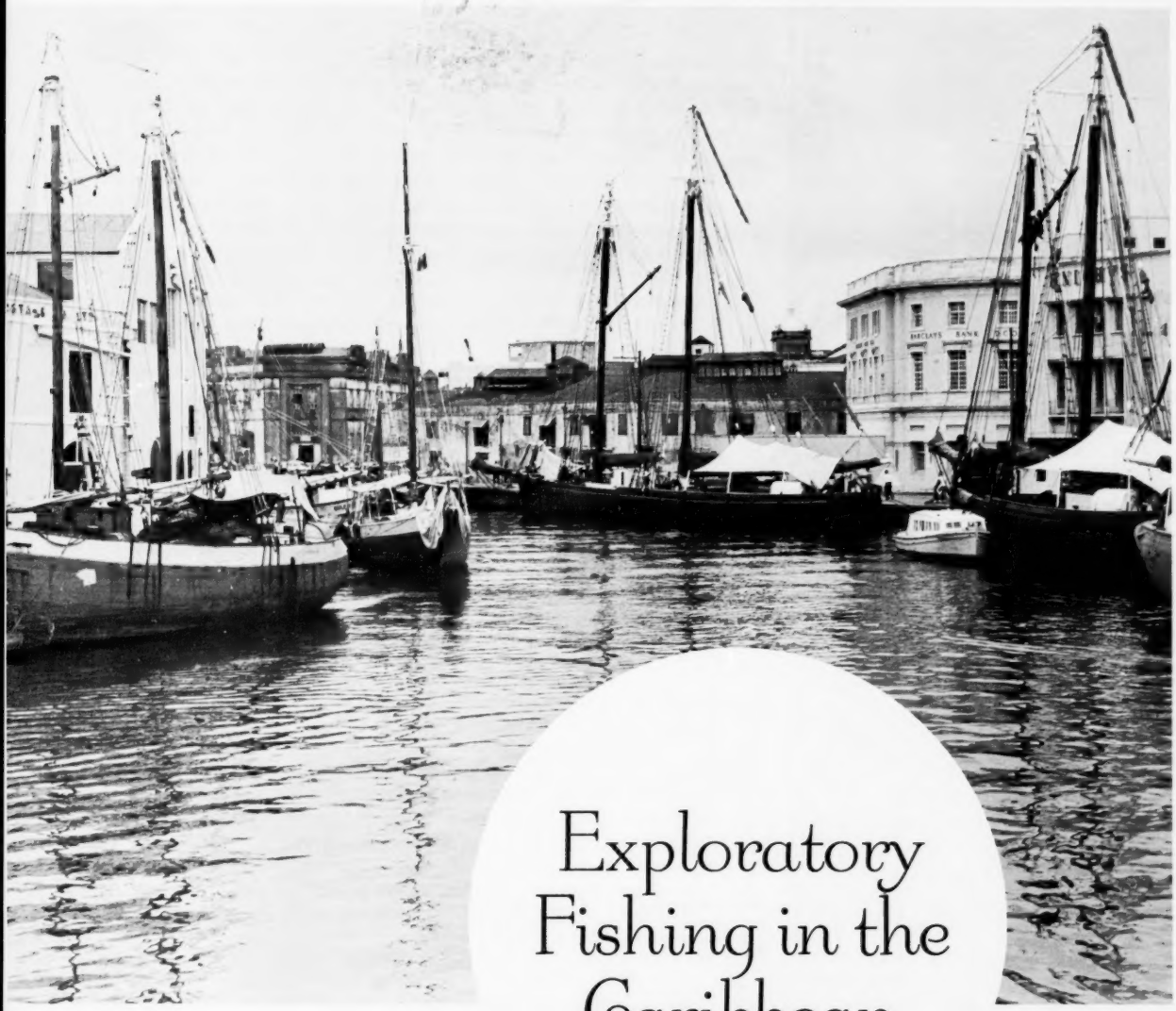

Exploratory Fishing in the Caribbean

U.S. DEPARTMENT OF COMMERCE
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Marine Fisheries Review

Vol. 36, No. 9
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CONTENTS

Articles

Cover.—The port of Bridgetown, Barbados. Photo courtesy of the Food and Agriculture Organization of the United Nations, by H. Menjaud.

MFR PAPER 1082

Exploratory Fishing Activities of the UNDP/FAO Caribbean Fishery Development Project, 1965-1971: A Summary

ROBERT S. WOLF and WARREN F. RATHJEN

ABSTRACT—The UNDP (United Nations Development Program)/FAO (Food and Agriculture Organization) Caribbean Fishery Development Project became operational in 1965. The Exploratory Fishing Section formed the largest component of the project; it was primarily staffed by FAO personnel, but was planned and directed by the U.S. National Marine Fisheries Service. Activities from 1965 to 1971 are summarized in this publication.

Beginning in 1966, nearly 2,500 sea days were spent by three vessels in resource experimentation and exploration. Operations extended from the Central American coastal shelf to the islands and banks off the Greater and Lesser Antilles and to the coastal shelves of eastern Venezuela, Guyana, Surinam, and French Guiana.

Experiments were conducted in attracting and catching pelagic fish by the use of longlines, live bait/pole-and-line, trolling, gill nets, lift nets, and handlines, and in catching demersal fish through the use of handlines, power reels, traps, longlines, trawls, and gill nets.

Exploratory efforts produced about 1 million pounds (453,597 kg) of usable food fish. Of this total, about 35 percent consisted of trawl-caught demersal fish, 38 percent of snapper, jacks, and fish of related species, 17 percent of sharks, and the remaining 10 percent mostly of pelagic fish.

Three major resources were delineated. The demersal trawl fishes are limited to the continental shelf off northeastern South America. The demersal snapper and related species exist throughout the project region, but are most concentrated on the edge of the Honduran/Nicaraguan continental shelf off Central America, on the banks of the northern Leeward Islands, and on the edge of the Guyanan/French Guianan continental shelf. A lesser resource, of sharks, occurs on the continental shelf of northeastern South America, and is concentrated off Surinam. A seasonal increase in availability of skipjack tuna to live bait/pole-and-line fishing was apparent during March through May in the Windward Islands. Pelagic species showed a seasonal increase in availability to trolling during the same period in the northern Leeward Islands and during September and October off Jamaica. Spiny lobsters were taken in good quantity in April on Pedro Bank south of Jamaica, but were not available on the other grounds in the project region. A small resource of tilefish was found in deep water off the edge of the Surinam continental shelf.

Accomplishments in the Exploratory Section of the UNDP/FAO Caribbean Fishery Development Project during the first year (1965) were limited to acquiring staff, ordering and receiving necessary equipment, and operational planning. Not until Novenber of 1966, after delivery of the MV *Calamar* and MV *Alcyon* from the builder, did actual operations begin. In June 1967, the MV *Fregata* was delivered and the three-vessel fleet was complete. Phase I of the project was completed on 31 August 1969, and Phase II on 31 August 1971.

The overall project can be described as a commercial feasibility or preinvestment survey of the fishery re-

EDITOR'S NOTE

This number of* Marine Fisheries Review *documents the results of a five-year international study of the fisheries potential of the Caribbean Sea.

The area surveyed under this study was immense, covering almost one million square miles. The countries involved in the study were Barbados; Guyana; Dominican Republic; France in respect to French Guiana, Guadeloupe, Martinique; Jamaica; Antigua; Montserrat; St. Christopher, Nevis, Anguilla; Netherlands Antilles; Surinam; Trinidad and Tobago; United States of America on behalf of Puerto Rico; Grenada; St. Lucia and St. Vincent.

Romantic names, these. Yet the West Indies are a good deal more than coconuts and steel bands and rum. Excluding the mainland countries of Guyana, French Guiana, and Surinam, the island countries in this study, although occupying wide arcs of the subtropical sea, have a total land area about the size of that of our small State of Maine. On these islands live more than 11 million people.

Only one aspect of this study has heretofore resulted in formal publication; yet the remainder of the material gathered provides a solid datum for future studies and development of fisheries in the Caribbean Sea.

This number of* Marine Fisheries Review *places in the permanent record a series of investigations that directly or indirectly affect the welfare of several million human beings and thus appear eminently worthy of preservation.

T.A.M.

Figure 1.—Caribbean Fishery Development Project Region.

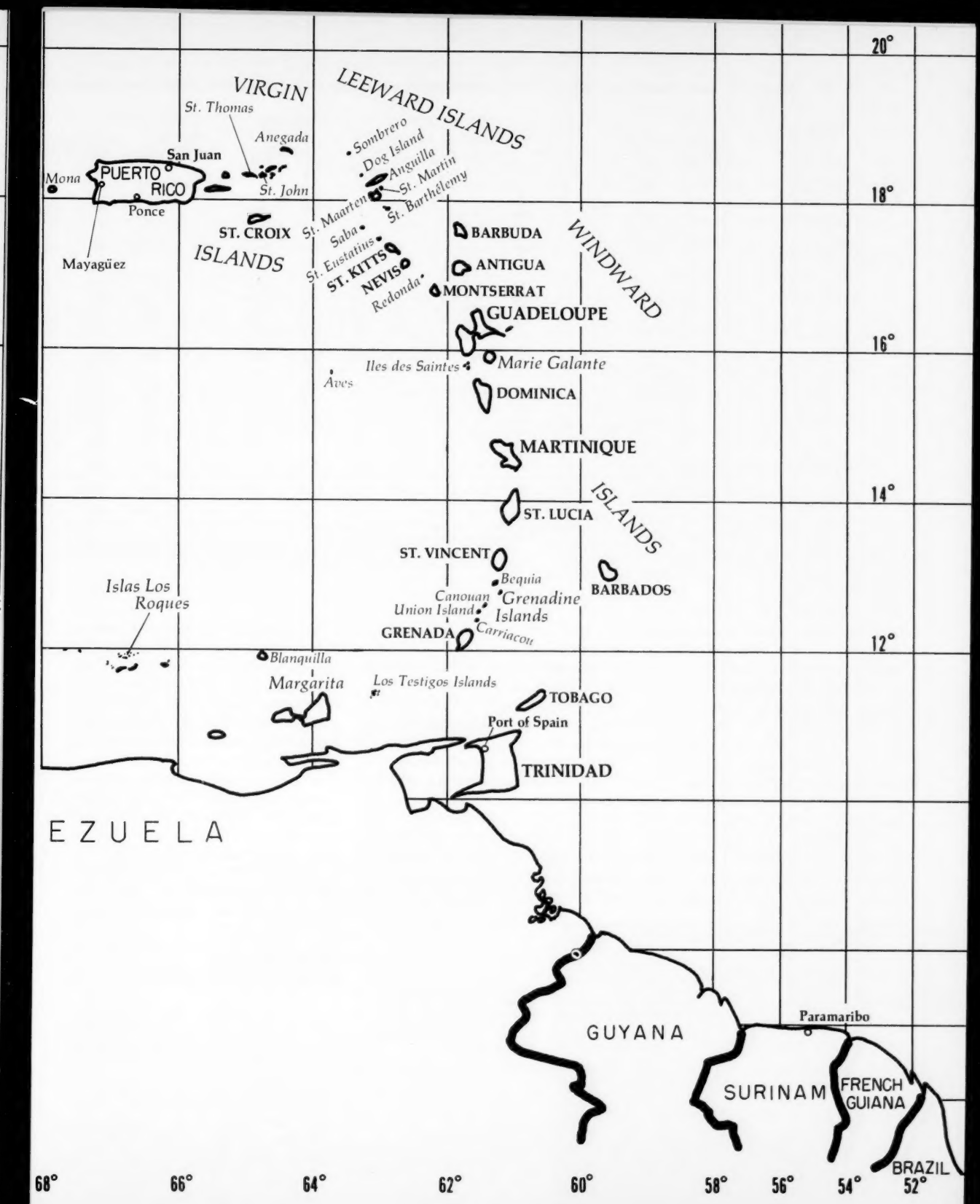
20°
18°
16°
14°
12°
VIRGIN
ISLANDS
LEEWARD ISLANDS
WINDWARD
ISLANDS
St. Thomas
Anegada
Sombrero
Dog Island
Anguilla
St. Martin
St. Barthélemy
San Juan
Mona
PUERTO
RICO
St. John
Ponce
Mayagüez
ST. CROIX
St. Maarten
Saba
St. Eustatius
ST. KITTS
NEVIS
Redonda
BARBUDA
ANTIGUA
MONTSERRAT
GUADELOUPE
Iles des Saintes
Marie Galante
Aves
DOMINICA
MARTINIQUE
ST. LUCIA
ST. VINCENT
Bequia
Canouan
Union Island
Grenadine
Islands
GRENADA
Carriacou
BARBADOS
Islas Los
Roques
Blanquilla
Margarita
Los Testigos Islands
TOBAGO
Port of Spain
TRINIDAD
EZUELA
GUYANA
Paramaribo
SURINAM
FRENCH
GUIANA
BRAZIL
68°
66°
64°
62°
60°
58°
56°
54°
52°

Table 1.—Summary of project exploratory operations by fishing method or other classification. Catch (CA) in thousands of pounds and effo

VESSEL & FISHING GEAR[1]	DEMERSAL TRAWLING		DEMERSAL HANDLINE & REEL		DEMERSAL POT OR TRAP		SHARK HANDLINE & SETLINE		PELAGIC TROLLING		PELAGIC LONGLINE		PELAGIC POLE & LINE		OTHER METHODS[2]	
Alcyon	CA	EFF	CA	EFF	CA	EFF	CA	EFF	CA	EFF	CA	EFF	CA	EFF	CA	EFF
1966-67	0	0	8.4	17	0.4[5]	0	0	0	0	0	19.9	84	0.8	55	0	0
1967-68	0	0	91.6	113	2.0[5]	0	0	0	0	12	0	0	1.4	79	0	0
1968-69	0	0	79.2	145	0	0	0	0	0	0	0	0	0.5	40	0	0
1969-70	0	0	23.7	14	28.7	153	0	0	5.9	24	0	0	0	0	0	0
1970-71	0	4	37.4	16	9.2	50	0	0	1.3	26	0	0	0	0	0	0
Alcyon Subtotals	0	4	240.3	305	40.3	203	0	0	7.2	62	19.9	84	2.7	174	0	0
Calamar																
1966-67	84.3	37	0	0	0	0	0	0	0	0	15.2	59	2.8	41	0	0
1967-68	155.9	198	0	0	0	0	0	0	0	0	0	0		0	0	0
1968-69	86.8	42	0	0	0	0	62.9	75	9.7	20	0	0	0	47	0.3	5
1969-70	14.1[5]	0	0	0	0	0	102.9	130	0	0	0	0	6.6	48	6.8	30
1970-71	0	0	18.2	57	28.8	92	0	0	5.6	18	0	0	0	0	0	19
Calamar Subtotals	341.1	277	18.2	57	28.8	92	165.8	205	15.3	38	15.2	59	9.4	136	7.1	54
Fregata																
1966-67	0	0	0	0	0	0	0	0	0	0	0	0	1.6	30	0	0
1967-68	0	0	0	0	0	18	0	0	0	6	0	0	5.9	96	2.4	40
1968-69	0	0	28.5	179	0	0	0	0	0	0	0	0	0	0	1.9	37
1969-70	0	0	12.8	53	0	0	0	0	0.2	11	0	0	11.5	86	0	0
1970-71	0	0	0	0	0	0	0	0	5.8	96	0	0	0	0	0	0
Fregata Subtotals	0	0	41.3	232	0	18	0	0	6.0	113	0	0	19.0	212	4.3	77
GRAND TOTALS	341.1	281	299.8	594	69.1	313	165.8	205	28.5	213	35.1	143	31.1	522	11.4	131
PERCENT OF TOTAL	28.5	11.3	25.0	23.8	5.8	12.6	13.8	8.2	2.4	8.5	2.9	5.7	2.6	20.9	1.0	5.2

[1] 1 September through August 31.
[2] Bottom and surface longline, bottom and surface gill net handline drift attraction, etc.
[3] Live bait fishing was incidental to pelagic pole and line fishing.

sources of the region. It was divided into three sections with over lapping operational scopes:

1. Exploratory fishing.
2. Marketing study and demonstration.
3. Fishery officers' and fishermen's training.

The Exploratory Fishing Section included definition of resources, experimentation with fishing gear and methods, simulated commercial fishing, and demonstration fishing for fishermen from participating countries. On-the-job training was also provided on the vessels for fishermen trainees.

Resource exploration was conducted in the waters of the Caribbean Sea, from the edge of the Central American continental shelf east to the arc of the Lesser Antilles (Fig. 1). Territorial and adjacent waters of the Central American countries, Colombia, and Venezuela were not under direct scrutiny of the Caribbean Fishery Development Project as they were within the study area of associated projects. In the Atlantic Ocean adjacent to the Caribbean Sea, some explorations were made in the waters near Hispaniola, Puerto Rico, and the Lesser Antilles. The continental shelf off northeastern South America between Margarita Island, Venezuela, and the border between French Guiana and Brazil was explored.

Under contract to FAO, the U.S. National Marine Fisheries Service (formerly Bureau of Commercial Fisheries) was responsible for planning, organizing, and supervising the exploratory fishing activities. The Chief of Exploratory Fishing and several specialist fishery consultants were employees of the National Marine Fisheries Service.

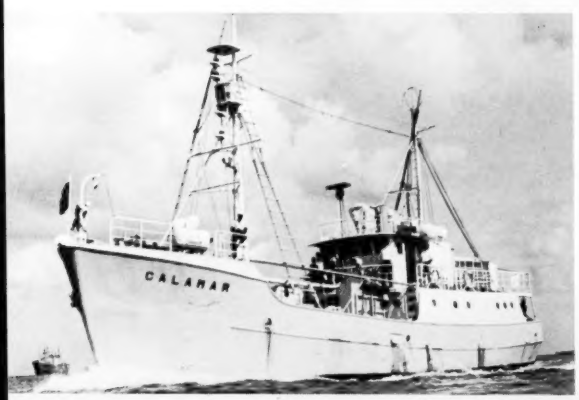

Figure 2.—The MV *Calamar*, one of two 82-ft FAO multipurpose fishing vessels assigned to the UNDP/FAO Caribbean Fishery Development Project, 1966-71.

EXPLORATORY FISHING OPERATIONS

The MV *Calamar* (Fig. 2) and the MV *Alcyon* are sister ships built for FAO in Japan. They were registered

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FF) in days of directed fishing are presented for each project vessel and fishing gear.

TOTAL FOOD FISH		LIVE BAIT LIFT NET[3]		LOBSTER & OTHER INVERTEBRATES		INDUSTRIAL FISH		OVERALL TOTALS	
CA	EFF	CA	EFF	CA	EFF	CA	EFF[4]	CA	EFF
29.5	156	6.4	—		0		—	35.9	156
95.0	204	10.9	—		0		—	105.9	204
79.7	185	4.4	—		0		—	84.1	185
58.3	191	0	—	1.3	0		—	59.6	191
47.9	96	0	—	0.5	64		—	48.4	160
10.4	832	21.7	—	1.8	64		—	333.9	896
02.3	137	7.2	—	0.2	0	24.4	—	134.1	137
55.9	198	0	—	0.7	0	47.5	—	204.1	198
59.7	189	5.8	—	0.2	0	62.8	—	228.5	189
30.4	208	5.5	—	0.3	0	19.4	—	155.6	208
52.6	186	0	—	0	0	0	—	52.6	186
00.9	918	18.5	—	1.4	0	154.1	—	774.9	918
1.6	30	1.8	—	0	0		—	3.4	30
8.4	160	10.9	—	0	28		—	19.3	188
30.4	216	0	—	0	0		—	30.4	216
24.5	150	5.5	—	0	0		—	30.0	150
5.8	96	0	—	0	0		—	5.8	96
70.7	652	18.2	—	0	28		—	88.9	680
82.0	2,402	58.4	—	3.2	92	154.1	—	1,197.7	2,494
82.0	96.3	4.9	—	0.3	3.7	12.8	—	100.0	100

[4] Industrial fish were caught incidentally during demersal trawl fishing.
[5] Catches are incidental to other directed fishing effort.

in and operated out of Barbados and Kingston, Jamaica, respectively. These are combination vessels, adaptable to longlining, trawling, live bait/pole-and-line fishing, trap fishing, reel fishing, and trolling. Sufficient space was provided for fishermen trainees. Specifications are given below:

Length (overall)	82 ft (24.8 m)
Beam	22 ft (6.65 m)
Draft	11.5 ft (3.5 m)
Power	380 hp
Speed	10 knots

The MV *Fregata* (Fig. 3) was built for FAO in England. Although registered in the Netherlands Antilles, she operated primarily out of Barbados. She also is a combination vessel, adaptable to trawling, gill netting, reel fishing, and trolling, and also has space for trainees. Her specifications are:

Length	56 ft (17 m)
Beam	16 ft (4.9 m)
Draft	8.7 ft (2.7 m)
Power	180 hp
Speed	8.0 knots

The masters of the vessels were internationally recruited FAO personnel. Other than captains, the crew consisted of West Indians recruited from countries participating in the project. Trainees spent periods up to 6 months aboard and performed in general as fishermen crew. In addition, on each cruise, a scientist "cruise leader" was responsible for exploratory operations and record keeping. Sometimes additional technical personnel were aboard, provided from project staff, counterpart staff (from participating countries), or other interested agencies (University of the West Indies, Bellairs Marine Laboratory, National Marine Fisheries Service, etc.).

Individual cruises ranged from a few days to 2 months, but were normally planned at 17 days for the larger vessels and 10-14 days for the MV *Fregata*. When possible a port stop was made for fish sales, fishing demonstrations, etc. Hydrographic observations, biological collections, drift bottle releases, and fish tagging for interested individuals and institutions were made as time allowed and priorities permitted.

As the project period was limited, it was necessary to emphasize exploratory activities that offered the greatest possibility for fishery development. Operational priorities were set on the basis of this general guide and were adjusted as results were received and analyzed.

RESULTS OF EXPLORATORY OPERATIONS

The overall results obtained from all project exploratory operations are presented in Table 1. Catch figures are shown by fishing method for food fish catches and by other general classification for additional catches. Ship effort is presented in days spent away from home port on fishing exploration and/or experimentation. In some cases, catches are shown without any corresponding effort. This was due to incidental fishing effort during cruises planned and devoted to another fishing method.

The total project effort of nearly 2,500 days resulted in a total catch of almost 1.2 million pounds of living marine resources. Nearly 1 million pounds of this was prime food fish. Of the food fish total, nearly three-fourths was composed of demersal

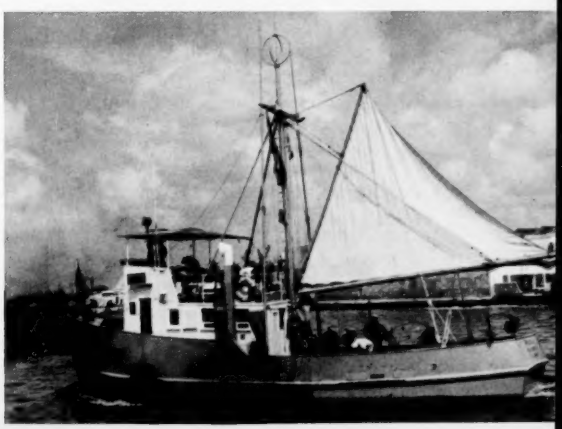

Figure 3.—The MV *Fregata*, a 56-ft FAO multi-purpose fishing vessel assigned to the UNDP/FAO Caribbean Fishery Development Project, 1967-71.

species taken by trawl, handline or reel, and pots. Effort for these species was almost one-half of the total. Over one-fifth of the total effort was devoted to live bait/pole-and-line fishing, but yielded only about 3 percent of the total catch.

Pelagic Fish Resource

The initial Caribbean Fishery Mission report (Kasahara and Idyll 1962) noted that the project area included an overwhelmingly large proportion of deep offshore waters. Even though these waters were generally low in productivity, some emphasis was programmed for assessment of pelagic stocks.

Longline Method

The results of fishing by the MV *Alcyon* and the MV *Calamar* through the longline method did not offer encouragement for substantial landings of tuna (Kawaguchi 1974b) or related species (Kawaguchi 1974a). Eighty-one tuna longline sets resulted in catches ranging from zero to three fish per set of hundred hooks. The relatively low rate of capture, inexperience of the crew, and the turnover of available trainees did not permit operations much in excess of 100 baskets (of six hooks each) of gear set per day. This figure contrasts with 250-400 baskets of gear set each 24 hours in a normal commercial longline operation.

Considering the recent standstill in commercial tuna longline fishing in the world and the results of their explorations, project personnel concluded that the development of a longline fishery by participating countries would not be profitable. The availability of the resource varies with location and season throughout the year. The annual variation is uncertain, and anticipated yields are not considered adequate for small local operations.

Live Bait/Pole-and-Line Method

In part because of the lack of success in longlining, considerable emphasis was placed on the live bait/pole-and-line method in fishing for pelagic species, principally skipjack tuna (*Katsuwonus pelamis*). This phase involved assessment of the bait fish resource as well as the available tuna resource and evaluation of the pole-and-line fishing method in the region (Wagner 1974).

Bait fishes were attracted to the vessel with lights and caught primarily by use of the lift or "blanket" net. Catches of live bait averaged 96 buckets (600 pounds; 275 kg) per baiting station (usually one night). Best locations for baiting were Jamaica, Puerto Rico, and Trinidad. The resource has the potential for intensified harvesting for both human consumption and bait.

Pole-and-line fishing produced catches ranging from nil to over 5,000 pounds (approximately 2,250 kg) per boat day, but averaging only about 100 pounds (45 kg) per day. During concentrated efforts to test the effectiveness of the method in the Windward Islands area during 1970, the catch per day averaged only 228 pounds (100 kg) for a 10-hour fishing day.

Even though stocks of tuna and other surface school fishes exist in the Caribbean, the pole-and-line fishing method did not show itself to be sufficiently productive to support a large-scale commercial industry. The availability and species composition of bait fish, their biting and schooling behavior, the seasonal abundance of target species, and the water and weather conditions all combined to keep catch rates below those required for such a venture. The method is capable of providing reasonable catches for a very few boats during seasonal periods of high abundance.

Bait fish appear to hold minor prospects for greater exploitation in the region. The calculated weight of all bait caught exceeded the catch of fish caught by pole and line by two or three times—although less effort was expended.

Trolling

Another fishing method utilized for catching pelagic species was trolling (Wagner and Wolf 1974). This method was used in nearly 7 percent (13 cruises—all vessels) of all project vessel time and nearly all sea time of the MV *Fregata* during the final year. Catch rates were low except on the banks north of Hispaniola and in the northern Leeward Islands. Here during the early months of the year average catches ranged from 18 to 30 pounds (8-11 kg) per fishing hour for an average of five lines. Deep trolling as practiced in the salmon fishery off the Pacific Coast of North America was also undertaken, but few fish were taken.

Other Fishing Methods

Other methods were experimentally applied to the pelagic resource. Their success was varied, but generally low in terms of production.

Gill netting was attempted under a variety of circumstances (Wolf 1974) with small- and large-mesh nets. Catches were generally poor, except for eight night sets off Trinidad when 38 shackles of 5-inch mesh nylon net caught over 2,000 pounds (900 kg) of Spanish mackerel (*Scomberomorus maculatus*), jacks, and sharks. Flying fish were extremely vulnerable to gill nets; however, this gear is already commonly used at Barbados.

Some experimental fishing effort was expended in attracting and concentrating pelagic species around floating objects (Wolf 1974). Methods of fishing included handlining, trolling, gill netting, and longlining. Catch rates were not high, but the use of artificial structures to concentrate pelagic fish such as flyingfish (Exocoetidae), jacks (Carangidae), wahoo (*Acanthocybium solanderi*), dolphin (*Coryphaena hippurus*), tunas (Scombridae), and sharks was successful.

Demersal Fish Resource

Trawling Method

Extensive trawling operations (Rathjen, Yesaki, and Hsu 1969), including exploration, demonstration fishing, and simulated commercial production fishing, were conducted during 19 cruises by the MV *Calamar* on the continental shelf off the Guianas, around Trinidad, and off eastern Venezuela. An extensive trawl resource consisting mostly of sciaenid fishes (sea trout, *Cynoscion virescens;* croaker, *Micropogon furnieri;* and whiting, *Macrodon ancylodon*) has been shown to exist between 5 and 20 fathoms on the continental shelf off the Guianas.

The overall catch rate was 676 pounds (306 kg) per trawling hour.

Of this catch, 68 percent was marketable fish, 28 percent was incidental or industrial fish, and 4 percent invertebrates. Production was highest off Surinam, averaging 735 pounds (334 kg) per hour. Of this catch, 44 percent was sea trout, 10 percent croaker, and 15 percent fish of other species. The best catch rate here was achieved during the period June through August, when nearly 1,000 pounds per hour were caught. Catch rate is positively correlated with fresh water outflow from the Surinam River. Daytime catch rates averaged 30 percent higher than nighttime with peak catches occurring between 6 a.m. and 9 a.m. The existing resource approximates 350,000 metric tons and a sustainable production of approximately 200,000 metric tons can be expected.

Handline Method

Nearly one-fourth of all project exploratory fishing effort was devoted to line fishing (powered reels) for snappers (Lutjanidae), jacks (Carangidae), and groupers (Serranidae), and fish of other related species throughout the project region. Average catch rates per line per 10-hour day by fishing area were: 350 pounds (160 kg) off the Honduran-Nicaraguan coasts; 150 pounds (70 kg) in the northern Caribbean; 100 pounds (45 kg) around the banks in the northern Leeward Islands; 15 pounds (7 kg) throughout the remainder of the Lesser Antilles and southeastern Caribbean; and 115 pounds (54 kg) on the edge of the continental shelf off the Guianas.

Considered by the results obtained during 5 years of exploratory fishing, the resource of demersal snappers and related species in the Caribbean and adjacent waters can support an increased annual production of 75,000 tons, if fully exploited. Present annual production by local fishermen on local grounds is estimated at 20,000-25,000 tons. Ciguatera fish poisoning will remain a deterrent to expansion of the fishery for snappers, groupers, and jacks in the northern Leeward Islands; an early solution to this problem does not seem likely (Kawaguchi 1974a).

Pot Fishing

Comparative pot (trap) fishing was undertaken for snapper and jack (Wolf and Chislett 1974) during 17 cruises by the three vessels.

The indigenous West Indian "Z" pot was compared primarily with the Australian "D" pot and to a lesser extent with the "O" pot and a space-saving nesting pot fabricated to project design. Various sizes of pots, sizes of mesh, baits, soaking periods, and fishing depths were compared. Overall catch rates for the "Z" pot averaged about 15 pounds (7 kg) per pot lift on the Jamaican Banks, north of Hispaniola, and off Venezuela, Guyana, and Surinam. Catch rates of about 40 pounds (18 kg) per lift were obtained in the northern Leeward Islands and off French Guiana. Catch rates were lowest, about 5-10 pounds (2-4 kg) per lift, in the Windward Islands. The "Z" pots out-fished the "D" at a ratio of about 2:1 and the other pots by a much greater ratio. Larger pots and small mesh sizes yielded a greater catch rate. Atlantic herring (*Clupea harengus harengus*), Spanish mackerel, and West Indian "robin" (scad) baits all produced about the same catch rate. The best overall catch rates were obtained from pots soaked for one day or less. The average size of snappers was greater with a larger sized mesh. A declining catch rate was observed during May, June, and July.

The greatest proportion of the catch from the Jamaica Banks consisted of grunts (Pomadasyidae), trigger fish (Balistidae), squirrel fish (Holocentridae), and porgies (Sparidae), taken as a group. North of Hispaniola, snappers and groupers contributed about evenly to the catches. Nearly 75 percent of the catch in the northern Leeward Islands, the Windward Islands, and on the South American shelf was snappers.

In all areas with offshore banks or having continental shelves of any magnitude, the catch rates were high enough to evoke commercial interest. The smaller banks off Jamaica would probably not support unlimited effort because of size, but they have potential. On the other hand, Pedro Bank is large enough to provide a good ground for Jamaican fishermen. The eastern end of the Bank receives some effort presently, but it is by small canoes carrying only a few traps, while the southern and western sides of the Bank are comparatively untouched. Silver and Navidad Banks both offer good trap fishing potential. In the northern Leeward Islands, banks near Saba and Barbuda have excellent potential, and Anguilla Bank has good potential. Gibbs Seamount has limited potential, due to small size. In the Windward Islands, the Grenada shelf has shown some moderate trap fishing potential. The waters off eastern Venezuela, Guyana, and Surinam have good potential, while French Guiana has excellent potential.

As mentioned, ciguatera poisoning is a deterrent to marketing demersal species from the northern Leeward Islands; but the apparently ciguatera-free silk snapper (*Lutjanus vivanus*) has contributed between 70 and 90 percent of the pot catch from 60 to 100 fathoms.

Other Fishing Methods

Bottom longline fishing for snappers and fish of related species produced unsatisfactory results (Kawaguchi 1974a). Sets in deep water (100-200 fathoms) off the end of the Guianan continental shelf produced catches of tilefish (*Lopholatilus chamaeleonticeps*) and grouper (*Epinephelus* sp.) up to 1.0 pound (0.4 kg) per hook off Surinam, but averaging only 0.5 pound (0.2 kg) per hook along the entire shelf edge.

Bottom gill net sets were generally nonproductive except for catches of bait fish in Kingston, Jamaica harbor and a catch of 417 pounds of mixed mackerels (*Scomberomorus* spp.), jacks, and sharks.

Explorations of the spiny lobster resource (Chislett and Yesaki 1974) did not indicate commercial potential on the northern Leeward Islands Banks, on the banks north of Hispaniola, nor on small banks south and southeast of Jamaica. Better results were obtained from the western end of Pedro Bank, located southwest of Jamaica, where catches up to 0.45 lobster per trap lift were observed. Incidental efforts in the Windward Islands and Trinidad were not generally productive.

Shark Resource

Experimental and exploratory fishing for sharks was conducted on the

continental shelf off the Guianas during eight cruises of the MV *Calamar* (Kleijn 1974). Fishing during daylight was done by handlining, a small trawl for catching bait, and at night with one or two sets of steel-cable bottom setline.

Over 4,600 sharks of 25 species, weighing over 165,000 pounds (74,820 kg) were caught. Nearly half were caught during 245 hours of handlining with 1-8 lines and about the same number were caught with 105 sets or 1,212 hours of steel-cable setlines with 100-175 hooks. Sharks were most abundant between 15 and 20 fathoms during November and December and off the mouths of the Iracoube and Coppename Rivers. The more common species were blacktip shark (*Carcharhinus limbatus*), smalltail shark (*C. porosus*), bull shark (*C. leucas*), and tiger shark (*Galeocerdo cuvieri*).

The whole area off the coast of the Guianas will yield an average of 3,000 pounds (1,360 kg) of dressed shark meat (about 60 percent of round weight) per 24 hours of fishing, i.e., 1,000 pounds (458 kg) with two steel-cable sets during the night and 2,000 pounds (907 kg) with handlining during the day alternated with required trawl hauls.

Because the catch rate of shark is initially high, and the stock rather small, overfishing could easily result from any intensive fishing efforts.

CONCLUSIONS

The results of explorations by project vessels, as well as others, coupled with analyses of ongoing fisheries indicate that fishery resources available to participating countries in the project are not vast, but several offer potential for expansion. Foremost is the trawl resource on the continental shelf off northeastern South America. The second most promising latent resource awaiting greater use is that of snappers, jacks, and groupers. The keys to development of these resources by project countries are training of fishermen in trawling, handlining, and reel and pot fishing for snappers, and the operation of fishing vessels of the size and endurance necessary for these offshore operations. Resources of shark and bait fishes, as well as various pelagic fishes available to live bait fishing and to trolling, are of insufficient magnitude to offer large-scale commercial development, but when and where they are abundant they could be important in increasing the supply of animal protein for local residents. Based on project experience, there appears to be little hope of development of a tuna fishery by the longline or live bait methods by participating countries in the project.

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MFR PAPER 1083

Handline and Longline Fishing Explorations for Snapper and Related Species in the Caribbean and Adjacent Waters

KYOTARO KAWAGUCHI

ABSTRACT — Explorations for snapper and related demersal species have been conducted in the Caribbean and adjacent waters by vessels of the Caribbean Fisheries Development Project. This report presents the results of those explorations which used the handline and bottom set longline methods on the under- or unexploited shelves and banks within the project region.

Three project vessels spent a total of 382 days conducting exploratory and simulated commercial type production fishing for snappers, groupers, and jacks. They produced about 291,000 pounds of fish which averaged about 760 pounds per fishing day or about 14.6 pounds/line/hour of fishing. The species composition of the overall catch was 51 percent snapper (Lutjanidae), 34 percent jacks (Carangidae), 6 percent groupers (Serranidae), and 9 percent other mixed species. The daily catch rates ranged from 0 to 137 pounds/line/hour. Fishing efficiency and catch rates are discussed.

Catch results as related to fishing ground, water depth, bottom type, fishing season, and species composition are examined. Results of experimental use of the bottom set longline method are given.

From exploratory fishing results it is estimated that annual production of snapper could be increased from two to four times by utilizing under- or unfished grounds.

INTRODUCTION

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The United Nations Caribbean Fisheries Development Project became operational in August 1965. The purpose, stated in the Project Plan of Operations (FAO 1965), was: To provide, through exploratory fishing, marketing study and demonstration, and training, a basis for the further growth of the fisheries of the Caribbean Region, by: (a) indicating the most promising ways in which the productivity of the fisheries can be increased; (b) setting up a nucleus of trained fishermen and fishery officers; and (c) demonstrating the most economic ways of developing domestic and export markets and defining those fields in which future capital investment can most fruitfully be applied.

Within these limitations, the Exploratory Fishing portion of the Project performed diverse exploratory and demonstration fishing for all major pelagic and demersal fish resources in the Caribbean and adjacent waters of interest to countries participating in the project. A variety of recognized successful fishing techniques were applied in order to conduct the most effective operation within the limited period available. The fishing efforts were typically directed toward areas unexploited or underexploited by local fishermen of those areas. Some work was carried out in nearshore waters in order to acquire comparative data or to demonstrate more efficient gear or methods. Progress and details of these efforts were, from time to time, published as consecutive Cruise Reports and Fishing Logs and made available to the participating authorities and other interests to provide up-to-date information. At the end of project Phase I (31 August 1969) interim progress reports covering the period from December 1966, when the project vessels began operation, to July 1969 were prepared on methods and results of principal explorations. These provided timely information on which to base commercial operations and planning for Phase II (August 1969-August 1971) explorations.

This report covers part of the work accomplished on one of the two most promising latent demersal fishing potentials in the region—namely, for snappers and related species using the handline method. The objectives of this work were: (1) Locating new or unutilized snapper fishing grounds. (2) Providing training in the use of mechanical and electrical handline methods. (3) Confirming available information on the snapper and related species resource. (4) Providing fish for experimental marketing demonstrations in participating countries. The results of snapper trap or pot work are reported in a separate paper (Wolf and Chislett 1974). Rathjen, Yesaki, and Hsu (1969) summarize demersal fishes available to otter trawls.

The Caribbean Sea is bounded by the Greater Antilles on the north, the Lesser Antilles on the east, the islands of Trinidad and Tobago and the north coast of South America on the south, and the east coast of Central America on the west. The total surface area eastward from the Jamaica Rise is about 800,000 square miles, from which the surrounding countries produce about 440 million pounds of fish (FAO 1968) annually. The continental shelves are generally very narrow in the Greater and Lesser Antilles area, with rather steep slopes descending directly into the ocean depths. Those off the north coast of South America and the east coast of Central America are relatively extensive and productive because of numerous river outflows or upwellings.

There are a number of banks or reefs along the Jamaica Rise between Nicaragua and Jamaica as well as in the Leeward Islands area. They are typically of coral and thus have a relatively rugged bottom. The edges of those banks or reefs are generally steep, dropping off from depths of 30 to 50 fathoms to 400-500 fathoms.

The local fishing industries are small, using mostly the daily beaching type craft at numerous locations due to a small number of natural or man-made harbors. This results in limited landings at a given location and prevents further development of necessary facilities. The typical fishing methods are pot fishing with some traditional handlining for demersal fish and boat or beach seining for pelagic fish, which seasonally approach shore. Gill nets or longlines are employed seasonally in very limited areas. The dominant northeasterly trade wind of the region limits small craft operation to the inshore leeward portions of the islands from October to May, while hurricane threats limit their fishing range during the rest of the season.

At present most of the inshore grounds near those populated islands are intensively fished and larger catches can be expected on the inshore grounds only from pelagic species whose migration routes pass nearshore.

There are a few foreign investments in fishing vessels and shore facilities in the Caribbean area, but these are almost entirely in shrimp, spiny lobster, and tuna. Otherwise, only snappers and related species on the eastern margins of the Central American continental shelf have been commercially utilized by foreign fleets to any extent. This leaves a number of unexploited or underexploited areas on the offshore banks or around unpopulated island shelves which possess the potential for increasing production by Caribbean countries utilizing an appropriate size of fishing enterprise. Dominant species on these banks or outer continental shelves are snappers (Lutjanidae), groupers (Serranidae), and jacks (Carangidae).

HISTORICAL REVIEW

Considerable exploratory fishing for these species throughout the area was conducted by the U.S. National Marine Fisheries Service research vessel *Oregon*. These efforts have employed a variety of fishing methods, such as bottom or mid-water trawling, handlining, bottom longlining, gill netting, and fish traps. Carpenter and Nelson (1968), stated that "Immediate increased snapper and grouper production can be realized through adoption of modern hook-and-line fishing techniques." They also state "limited scale fisheries should be sustainable throughout the Antilles, although they would almost necessarily be a hook-

and-line or trap nature, since relatively little trawlable bottom exists." Gulland (1970) estimates a range of values for the potential annual catch of larger bottom fish from the Caribbean, including off eastern Venezuela, from 50,000 to 200,000 tons. He also feels that this range is in reasonable agreement with the snapper and grouper estimate of 41,000 tons by Carpenter and Nelson. These figures indicate an optimistic target for the increase of demersal fish production by participating project countries in the Caribbean.

From these potential stocks, a full-scale commercial fishing effort by Japanese vessels was attempted by two 110 ton modified tuna longliners based at St. Martin from August 1967 to March 1968 (Anonymous 1967). From two to four catcher boats (2-ton type) were shipped on the larger vessels for mothership operation, utilizing handlines and bottom longlines. During the 8-month period, one vessel produced 240,000 pounds of fish valued at U.S. $45,600 from the entire Caribbean area, while the other caught 395,000 pounds of fish (U.S. $78,400) from only the Leeward Islands area. For various reasons, including marketing problems caused by some of the fish from the Leeward Islands being ciguatoxic, the Japanese operations were discontinued.

In Jamaica in December 1968, the first commercial snapper reel fishing was initiated by a fishermen's cooperative. They purchased a secondhand Florida type snapper vessel, 51 feet length overall (LOA), and manned it with Jamaican fishermen. A skilled U.S. snapper fisherman was employed as captain. The boat fished mostly the offshore banks southwest of Jamaica and produced nearly 150,000 pounds of fish valued at U.S. $35,700 by November 1969, making a total of 14 cruises, each averaging about 2 weeks. The result was economically feasible to them and encouraged further enterprises using cooperative operation.

Off the north and northeastern coasts of South America, a commercial red snapper fishery has existed for past decades along the broad continental shelf. Four vessels, ranging from 70 to 90 gross tons and fishing from Martinique, land about 1,000 metric tons of snapper annually. They regularly call at French Guiana where another five snapper vessels (35 to 39 tons) are based (Fourmanoir 1968). A local schooner (size unknown) in Guyana caught 36,500 pounds of snapper and grouper valued at U.S. $11,000 during 16 trips in 11 months with a crew of nine (Allsopp 1958). Ten similar vessels based in Guyana produced a total of 284,451 pounds of fish in 1958. In the adjacent Gulf of Mexico, a snapper and grouper fishery has existed for over a century. In 1962, the U.S. snapper fleet of nearly 300 vessels produced a total of 18.2 million pounds valued at $3.58 million (Carpenter 1965). The average catch per vessel is calculated at approximately 61,000 pounds or U.S. $12,000 a year. The fleet has tended to increase since 1955. It appears that in Guyana the rapidly growing offshore shrimp industry, commencing in about 1958, may have retarded development of the snapper fishery by diverting the available manpower to it. The owner/skipper operation may become the next approach for the majority of the local fishing industries in the Caribbean.

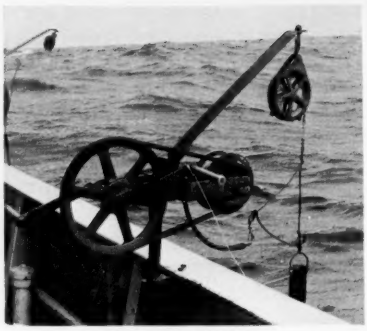

Figure 1.—Hand reel.

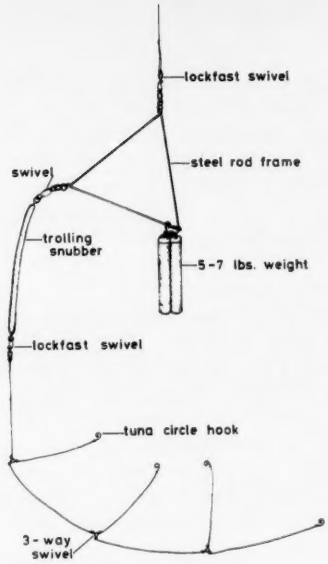

Figure 3.—Diagram of terminal gear used with powered snapper reels during project explorations.

Figure 2.—Electric reel.

VESSELS, GEAR, AND FISHING PROCEDURES

Vessels

Each of the three project vessels, *Alcyon*, *Calamar*, and *Fregata*[1], was used for exploratory fishing during the project life. *Alcyon* and *Calamar* are sister vessels built in Japan in 1966. They were designed for multipurpose exploratory fishing and training. They are offset house side trawlers. Each vessel accommodates eight crew, eight trainees, and two technicians. *Fregata* is a bridge forward seiner style steel vessel designed for combination fishing and training. It accommodates 10 persons. The *Calamar* and *Fregata* were operated from Barbados while *Alcyon* was based in Jamaica. The crews were made up of local fishermen/trainees except for captains, who were FAO masterfishermen.

[1]See paper by Wolf and Rathjen, this number, for photographs and specifications.

Fishing Gear

Principal gear used for the exploratory snapper fishing were handline gear and some experimental use of bottom longline. Descriptions follow.

Handline gear

Types of handline gear used were (1) traditional hooks and line, and (2) mechanical reels—hand powered and motorized (electric).

The hook and line outfit was constructed of 100-150 pound breaking strain monofilament nylon mainline about 200 yards long, with one end tied to a wooden winding frame and the other end fastened to a ½-1½ pound iron weight with a lighter thread. From three to five 150-pound test standard swivels (size number 1) or three-way swivels were attached to the mainline at equal intervals of about 1½ feet from the weight. To each swivel was tied about a foot of 55-75 pound test nylon line with a hook at the free end (Mustad-O'Shaugnessy)[2] number 4/0 (for yellowtail snapper) to number 6/0 (for large jacks or groupers). Exclusive use of this gear was made only for the first cruise of the *Alcyon* (cruise 67-6). Thereafter mechanical snapper reels were the main gear although the handlines were used occasionally for shallow water snappers.

The mechanical snapper reels used were a bicycle type of hand reel (Fig. 1) and an electric motor driven reel (Fig. 2). Six hand reels were used on the *Alcyon* until December 1968, when two of them were replaced by electrical reels. The electrical reel is driven by a modified automobile generator powered from a 12-volt heavy duty marine battery. This reel has a designed line take-up speed of 50 fathoms per minute running free and about 41 fathoms per minute under heavy load. After *Alcyon's* successful use of the two electric reels for six cruises, the remaining hand reels were replaced by electric reels for the rest of the period. *Fregata* used five electric reels while *Calamar* used five electric reels and one hand reel during her snapper exploratory fishing periods.

Typical gear fitted on the hand or electric reel was a 3/64 inch stainless steel line with a terminal rig (Fig. 3) introduced by a skillful Gulf of Mexico snapper fisherman from the United States assigned to the project as a snapper fishing consultant. The terminal rig is made of a triangle-shaped wire (8 S.W.G.) with a 5-7 pound iron weight on one bottom corner and a rubber snubber plus a short 250 pound test monofilament line with usually three snoods on another bottom corner, the top corner being secured to the main steel wire by a lockfast swivel. Hooks used on the snood were number six to nine tuna circle.

Bottom longline gear

Bottom longline gear was fabricated in units of baskets. A basket of longline was comprised of a 60-fathom mainline to which were attached 18-inch long 160-pound test nylon monofilament leaders spaced 4 fathoms apart (except for the first two cruises of *Fregata* which used a 2-fathom interval). Seven to ten baskets were joined together in one line to make a set. The main line was made of a ¼-inch diameter, tarred "Kuralon" rope commonly used for tuna longline gear. The hooks used were number six or seven tuna circle. Weights and floats were attached to the line at intervals so that the gear was suspended just above the bottom. This method was used mostly by *Fregata* and a few times by *Alcyon*.

Bait

The most common bait used for line fishing was imported frozen squid (*Loligo* sp. and *Daryteuthis* sp.) and Spanish mackerel (*Scomberomorous maculatus*). There was some use of herring (*Clupea harengus*), Pacific saury (*Cololabis saira*), and Pacific mackerel (*Scomber japonicus*). Some native fish baits such as Atlantic thread herring (*Opisthonema oglinum*), bumper (*Chloroscombrus chrysurus*), and fourwing flyingfish (*Hirundichthys affinis*) were tested as well. The squid and bait fish used were cut to proper size to cover a hook.

Fishing Methods

Handline and reel fishing

Handline gear and mechanical reels were mostly used from the starboard side and the stern. The mechanical reels were mounted along the inside of the starboard bulwark at about 10-ft intervals on the *Alcyon* and *Calamar* (Fig. 4). On the *Fregata* three reels were fixed on the starboard side and two on the port side. A bait board fitted to the gunwale and a bait cutting knife were provided for each reel operator. Gear repairing tools such

[2]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Figure 4.—Hand reels mounted inside of *Alcyon's* bulwark.

Table 1.—Fishing log—handline and reel fishing cruises for snapper and related species.

Cruise No	Month	Date	Area covered	Sea-days	Snapper fish.-day	Fish.-effort (line-hour)	Total Catch no	Total Catch lbs	Snappers no	Snappers lbs	Groupers no	Groupers lbs	Jacks no	Jacks lbs	Others** no	Others** lbs
A.* 67- 6	June July	19- -16	Pedro Bank, Rosalind Bank and Walton Bank	16	15	777	3,846 (+?)	7,627	3,364	6,230	259	361	44	252	179 (+?)	784
A. 67- 8	Sep.	7-24	Mona Passage, Silver & Navidad Banks	17	5	266	480	1,348	179	441	249	630	14	85	38	192
A. 67- 9	Oct.	8-14 16-20	SE of Morant Cay	10	3	67	113	340	30	101	47	132	17	74	(+?) 19	33
A. 67-10	Nov.	1-11 16-27	Pedro Bank	22	19	1,586	4,632 (+?)	12,547	2,907 (+?)	8,077	856 (+?)	1,512	294 (+?)	1,720	575 (+?)	1,238
A. 68- 2	Feb.	7-25	Pedro Bk., Rosalind Bk., Alice Sh'l east of Central America	19	15	639	3,396	11,675	2,391	6,894	190	945	534	3,261	281	575
A. 68-3a	Mar.	13-30	Monte Cristi Bk., Navidad and Silver Banks	(40)	11½	523	2,841	12,086	2,445	10,269	111	408	201	1,027	84	382
A. 68-3b	Apr.	3-22	Virgin Island Shelf Northern Leeward Islands	40	11	589	1,920	9,222	1,537	6,191	123	1,586	213	1,237	47	209
A. 68- 4	May	9-23	Rosalind, Alice Shoal East of Central America shelf	14	12	1,303	4,635	22,704	1,620	7,042	67	233	1,698	12,156	1,250	3,273
A. 68- 5	June	8-17	East of Central America	9	6	451	4,998	17,592	349	889	14	150	4,091	15,549	544	1,004
A. 68- 9	Dec.	4-18	Pedro Bk., Rosalind Bk., & East of Central America	14	12	663	4,775	13,565	2,064	4,847	98	470	2,059	7,004	554	1,244
A. 69- 1	Jan.	9-27	Pedro Bk., Mackerel Bk., New Banks, Blossom Bk., California Bk.	18	12	694	1,872	6,698	1,198	4,331	168	354	107	543	399	1,470
A. 69- 2	Feb.	10-26	Monte Cristi Bank, Navidad and Silver Bank	16	11	366	1,819	7,125	1,518	5,789	85	323	196	886	20	127
A. 69- 3	Mar.	11-28	Navidad Bank, Mona Passage Puerto Rican coasts	17	10	750	1,093	4,458	818	3,404	114	478	91	406	70	170
A. 69- 4	Apr.	10-24	East of Central America	14	11	1,104	5,068	22,087	2,032	5,004	34	212	1,959	13,000	1,043	3,871
A. 69- 5	May June	10- -4	Northern Leeward Is.	24	14	660	1,631	6,213	1,494	4,427	74	1,250	60	516	3	20
A. 69- 6	June	16-20 21-30	Pedro Bk., Rosalind Bk. East of Central America	14	8½	310	4,227	11,192	804	1,806	67	230	2,898	7,764	458	1,392
A. 69- 7	July	14-17 21-24	SE of Morant Cay Pedro Bk., Mackerel Bk.	6	5	126	386	1,469	348	1,164	14	180	17	115	7	10
A. 69- 8	Aug.	5-18	Pedro Bk., Alice Shoal SE Coast of Jamaica	13	12	601	1,249	4,557	962	3,672	129	309	88	447	70	129
A. 70- 8	Aug.	11-25	East of Central America	14	10	1,008	9,804	23,719	5,252	9,717	82	347	3,837	12,291	633	1,364
A. 70- 9	Sep.	16-27	East of Central America	11	8	1,179	9,971	24,679	3,720	7,329	28	188	4,477	13,318	1,746	3,844
A. 70-10	Oct.	1-8	East of Central America	7	4	438	6,468	12,722	3,073	5,800	6	15	1,652	3,495	1,737	3,412
21			*Alcyon*'s total	315	215	14,100	75,224	233,625	38,105	103,424	2,815	10,313	24,547	95,146	9,757	24,743
C. 70- 9	Oct.	7-28	Off French Guiana	21	14	404	1,237	6,208	1,095	4,080	100	1,619	35	499	7	10
C. 70-10	Nov.	12-27	Off Surinam	15	10	91	369	1,314	283	893	80	415			6	6
C. 70-11	Dec.	3-18	Off Guyana	15	12	198	1,899	10,702	1,810	9,865	62	725	7	79	20	33
F. 68- 1	Jan. Oct.	9-26 21-	Netherland Leeward Islands	17	3	12	9	50			3	10	4	38	2	2
F. 68- 8	Nov.	-18	Lesser Antilles — North	27	16	600	1,867	8,289	1,632	6,582	60	865	147	812	28	30
F. 68- 9	Dec.	2-18	Lesser Antilles — Middle	16	10	312	85	140	52	95	3	9	11	27	19	9
F. 69- 1	Jan. Feb.	8-25 14-	Lesser Antilles — South	18	12	405	125	542	93	418	4	64	17	54	11	6
F. 69- 2	Mar.	-7	Lesser Antilles — South	21	7	512	446	1,556	305	946	24	171	75	395	42	44
F. 69- 3	Mar. Apr.	17-29 14-	Barbados	13	11	222	43	97 (+?)	16	17 (+?)	4	32	13	40 (+?)	10	8
F. 69- 4	May May	- 4 20-	Lesser Antilles — North	21	13	408	1,840	7,370	1,567	5,018	59	952	119	653	95	747
F. 69- 5	July July	- 5 28-	Netherland Leeward Islands	46	23	514	209	670	85	136	44	189	23	163	57	182
F. 69- 6	Aug.	-26	Off Surinam & Guyana	29	14	746	1,916	7,263	1,749	5,789	138	1,180	14	199	15	95
F. 69- 7	Sep. Sep.	15-20 29-	Off Guyana	5	1	25	10	6	10	6						
F. 69- 8	Oct. Nov.	-23 10-	Off Surinam	24	12	631	1,134	5,280	1,098	4,713	33	548	2	19		
F. 69- 9	Dec.	-16	Off Guyana	36	7	314	1,150	7,487	1,142	7,419	4	14	4	54		
36			Grand total	639	380	19,494	87,563	290,599	49,042	149,401	3,433	17,106	25,018	98,178	10,069	25,915

*A represents *Alcyon* cruise, C. for *Calamar* and F. for *Fregata*.
**Including rainbow runner.

as wire cutters, pliers, a crimping tool (Nico-press) for wire and nylon lines, and scoop nets and gaffs for large fish were provided at a rate of about one for three operators. A fish gutting table and knives, washing tank, and a few sets of marker buoys with anchors and a grapnel to take up the marker buoy were also necessary for the operation. Bait was used at a rate of about 15 pounds per day per line or reel. Depending on the vessel, 5-12 tons of ice were carried. This was used at a ratio of about 1 pound of ice for a pound of fish.

On a typical exploratory fishing expedition an area would be chosen and fishing operations conducted on transects near and on the slope edge of the bank, or shelf, or at a recognized depth range on the shelf such as 30 to 45 fathoms for red snapper or 14 to 25 fathoms for yellowtail snapper.

Electronic depth sounding machines were fully utilized over the fishing ground to record bottom topography and evidence of fish concentration. When the machine traced a hard or rugged bottom, a ridge, or any abrupt transformation of the slope edge, a closer examination was made by cutting across it from many directions at slow speed. At a likely spot on slope edges or upon recording a school of fish, fishing tests were made. If the result was good, an anchored marker buoy was usually set to facilitate maintaining position. The buoy made it easier to determine current movements as well. Fishing was commonly accomplished while drifting or by keeping the vessel against wind and current by repeated use of engine and rudder for position keeping. This maneuver keeps the fishing lines close to the vessel to reduce fouling and permit a better feel of the fish biting. The drift was repeated until biting slacked off or was considered sufficient for evaluation. Occasionally the vessel was anchored over a likely fishing spot.

Typically fishing was conducted only during daytime for deepwater snapper, but on grounds where yellowtail snappers and jacks were abundant efforts were made intermittently throughout both day and night by concentrating on the biting periods as noticed by the deck watchman who operated a few monitoring lines.

Catch results were recorded and notations were made on species and size of fish, number and weight captured, number of lines, type of bait, duration, and depth (range) of fishing. Some biological data such as gonad stage, sex, or stomach content were also collected whenever time permitted.

Special care was paid to the handling and preservation of the catch for further marketing demonstrations on shore. The fish were gutted and washed carefully. When time permitted they were arranged in a plastic fish box belly down and stored in the iced fish hold. When conditions did not permit boxed storage the fish were iced in the conventional manner and boxed during unloading.

Bottom-set longline fishing

This method was conducted during four coastal multipurpose cruises and four snapper reel fishing cruises by *Fregata*. In these cruises 3-10 baskets were used. Each basket was baited and joined in one line; floats and weights were attached along the mainline on a chute fixed on the stern deck (Fig. 5). After surveying the bottom the vessel steamed in one direction as the set was made by hand passing from one basket to another throwing first line, then the hook, repeatedly. The gear was anchored at each end and marked with a flag buoy tied to one end of the lift rope, the other end of which was connected to either end of the serial baskets of line.

The gear was fished 2-5 hours and then retrieved by a hydraulic longline hauler on the starboard deck through a side roller mounted on the gunwale. Catch records similar to those previously mentioned were obtained.

Production fishing

Ten simulated commercial type production fishing cruises for snapper and related species were carried out to demonstrate commercial feasibility during the project period. Typically the fishing was accomplished by a mothership operation, with *Alcyon* acting as a mothership or base for up to three maneuverable small catcher boats. A variety of catcher boats—local dug-out canoes, 19-foot dories familiar on the Grand Bank of Newfoundland, an 18-foot plywood runabout boat, and a 16-foot work boat—were used. The fishing methods used were primarily mechanical reels on the *Alcyon* and handlines on the catcher boats. Up to eight local commercial fishermen from Jamaica were employed at full share-pay basis (50 percent of their catch) to fish from the catcher boats or from *Alcyon*.

These cruises were conducted on known productive grounds. The fishing operations were not restricted to either daylight or dark hours, but were continued as long as they were

Figure 5.—Setting bottom longline from *Fregata*.

Table 2.—Fishing hours, catch rate, and catch composition by area and bank.

Area	Total hours and days fished (hrs)	(days)	Catch rate lb/line/day	Catch composition (% in weight) Snapper	Jack	Grouper	Grunt	Other[2]
Jamaica south to southwest waters								
Jamaica Coast and vicinity banks	29.1	4.5	[1] 6 (4)[2]	52.7	17.9	18.5	4.3	6.5
Banks SE of Morant Cay	24.9	4.5	49 (27)	47.7	24.6	19.3	1.1	6.8
Mackerel Bank	62.5	8	103 (81)	69.7	5.2	4.5	0	19.8
Walton Bank	3.4	0.5	3 (2)	0	0	100	0	0
Pedro Bank, East	174.9	14.5	79 (95)	74.5	11.9	9.7	2.8	1.1
Pedro Bank, South	18.7	2	25 (23)	39.4	3.9	21.9	8.8	26.0
Pedro Bank, SW	263.5	22	76 (92)	71.7	6.8	8.5	3.9	9.2
Pedro Bank, West	25.5	2	40 (51)	76.2	18.8	5.2	0.9	2.6
Pedro Bank, NW	32.0	3	180 (191)	91.6	3.2	2.2	0.4	0.1
Alice Shoal	75.0	5.5	87 (119)	59.3	25.1	11.0	2.0	2.6
Rosalind Bank	46.1	6	109 (85)	58.7	25.3	9.5	3.1	3.5
A bank between Rosalind and Honduras	33.7	2	88 (148)	53.6	37.2	5.2	4.0	0
East of Honduras, 2nd shelf (E)	180.1	14.5	94 (130)	69.7	16.3	4.1	5.3	4.5
2nd shelf (W)	21.7	2	105 (115)	50.8	22.9	18.2	4.6	3.4
1st shelf	32.3	2	71 (114)	32.3	56.7	7.4	3.6	0
East of Nicaragua	581.6	56.5	270 (276)	26.2	60.8	1.5	2.4	2.0
Total[4]	1,605.0	149.5	W.M.[5] 151 (161) U.M.[6] 87 (97)					
Hispaniola to Virgin Islands								
Monte Cristi Bank	91.7	13	150 (110)	87.0	5.2	4.6	2.3	0.8
Silver Bank	58.5	5	132 (153)	80.2	6.6	10.2	1.2	1.8
Banks between Silver and Navidad Bank	15.0	1	27 (40)	13.3	9.9	65.7	5.8	5.3
Navidad Bank	108.0	11.5	245 (229)	78.9	12.5	5.6	0.8	2.3
Mona Passage	53.3	6	21 (18)	45.7	12.5	36.8	0	5.0
Puerto Rican Coasts	35.4	4	69 (51)	64.9	18.0	15.5	0	0.9
Shelf and Banks around Virgin Is.	50.5	5	154 (156)	61.2	15.0	21.7	0	1.4
Total	412.4	45.5	W.M. 145.0 (132) U.M. 114.0 (108)					
Leeward Islands Waters								
Sombrero Bank	36.1	3.5	110 (114)	90.5	2.8	6.5	0	0.2
A bank SE of Sombrero	8.5	1.5	184 (156)	86.8	6.3	6.9	0	0
Anguilla Bk. NW edge	8.5	1.5	76 (43)	62.0	13.0	19.3	0	5.6
Anguilla Bk. N edge	35.9	4	174 (156)	64.9	12.4	22.5	0	0.2
Anguilla Bk. NE edge	19.9	3.3	99 (60)	58.6	6.4	30.2	0	4.7
Anguilla Bk. E edge	183.6	13.5	159 (215)	68.0	11.1	14.7	0	6.3
Anguilla Bk. SE edge	10	1	59 (59)	49.7	9.5	40.8	0	0
Saba Bank	6.3	1	20 (12)	57.3	12.1	25.8	4.8	0
Barbuda Bank N to NE edge	44.6	4.8	123 (116)	80.4	10.1	8.9	0.1	0.4
Barbuda Bk. W edge	67.7	8	140 (118)	84.9	8.0	7.2	0	0
Barbuda Channel East edge	1.1	0.3	69 (30)	100	0	0	0	0
Antigua SE to S edge	5.9	0.8	0	0	0	0	0	0
Nevis Is. (SW)	7.4	1	2 (2)	100	0	0	0	0
Redonda (NE)	2.7	0.5	97 (52)	53.4	0	46.4	0	0
A bank NE of St. Kitts	2.7	0.5	7 (4)	100	0	0	0	0
Haver's Shoal and Montserrat	25.7	3	83 (71)	84.0	11.5	4.4	0	0
Guadeloupe	6.9	6	7 (5)	72.0	15.9	8.4	0.8	2.9
Dominica	7.1	0.8	15 (10)	15.4	84.6	0	0	0
Offshore banks SE of Dominica	7.5	1.8	1 (1)	0	85.7	0	0	14.3
Total	488.1	56.8	W.M. 116 (101) U.M. 75 (64)					
Windward Islands waters								
Martinique (ESE)	18.0	2	3 (3)	42.2	33.3	8.9	8.9	66.7
St. Lucia	59.6	7	17 (15)	79.2	8.1	12.7	0	0
St. Vincent	3.5	1	2 (2)	33.3	0	0	0	66.7
Barbados	86.4	9	2 (2)	9.7	37.5	46.5	0.7	5.6
Traders Bank	11.0	0.5	28 (28)	30.6	67.1	2.3	0	0
Grenadine	58.6	6	5 (5)	41.2	17.6	31.9	3.3	6.0
Grenada (SW)	29.2	2.3	88 (88)	65.3	31.5	1.7	0.9	0.6
Total	266.3	27.8	W.M. 16 (15) U.M. 21 (20)					
Shelves NE of S. America								
Aruba, Curacao and Bonaire	120.8	23	13 (7)	20.3	24.3	28.2	0	27.2
Trinidad and Tobago	83.0	12	34 (23)	61.6	9.5	27.7	0	1.2
Venezuela East Coast	27.4	7	55 (21)	53.8	0.4	44.7	0	1.0
Guyana	139.9	19	258 (178)	94.6	1.7	3.5	—	0.1
Surinam	159.8	21	88 (67)	82.1	2.8	13.8	—	1.3
French Guiana	156.8	22	126 (89)	76.0	4.9	18.8	—	0.1
Total	566.9	81	W.M. 189 (132) U.M. 112 (756)					
Grand total	3,460	382	W.M. 129 (117) U.M. 78 (74)	51.4	33.8	5.9		8.9

[1]Catch rate is total weight of catch in pounds per one line equalized to ten fishing hours per day from actual catch rate obtained from the project vessels.
[2]Catch rate in parenthesis is actual catch rate (catch + hours fished).
[3]Other species include rainbow runner.
[4]Local fisherman's effort and catch from production fishing cruise are not inlcuded.
[5]W.M. = Weighted mean of catch rate from total fishing efforts and catch in the area.
[6]U.M. = Unweighted mean of catch rate for total area.

productive and the stamina of the crew allowed. Catches were recorded and stored as those in exploratory fishing except that the local fishermen's catch was stored in marked plastic fish boxes.

AREA AND PERIOD COVERED

The region of project exploratory operations was basically all the Caribbean waters eastward from the Jamaica Rise including adjacent waters and off the northeast coast of South America—Guyana, Surinam, and French Guiana. Since emphasis in selecting areas to be fished was made primarily for the interest of project participants, the northern shelf of South America off Venezuela, the inner shelf east of Central America, and the coastal waters of Haiti were not included.

During exploratory line fishing for snapper and related species, a total of 587 sea-days was spent making 38 cruises and 382 actual fishing days during the 5 years of vessel operations.

The Jamaica-based *Alcyon* was used to cover the northern region of the Caribbean from the eastern margin of the Central American shelf eastward to the Leeward Islands. Utilizing handlines and reels, she spent 315 sea-days during 21 months in four consecutive years (1967 to 1970) with 215 actual fishing days. This included six exploratory fishing cruises and nine simulated commercial production demonstration cruises to the southwestern waters off and around Jamaica, four exploratory fishing cruises from north of Hispaniola to Puerto Rico, and two exploratory cruises in the Leeward Islands waters.

With the same method as *Alcyon* the Barbados-based vessels, *Fregata* and *Calamar*, spent a total of 272 days conducting exploratory fishing in the waters along the Lesser Antilles arc, the Netherlands Antilles (Aruba-Curacao-Bonaire), and off northeast South America. Their operations covered a total of 17 months from 1968 to 1970 with a total of 15 cruises and 165 actual fishing days. This included some repetitive cruises to the same area. *Fregata* did exploratory fishing from the Leeward Islands to northeastern South America including the Netherlands Antilles with a repeated cruise to the Leeward Islands and Netherlands Antilles for seasonal coverage. *Calamar* was used for further extensive coverage on the northeast South American shelf for three cruises during late 1970 where *Fregata* had completed limited coverage during the later half of 1969.

Geographic coverage using bottom set longlines was limited to some shelves of the Windward Islands and Netherlands Antilles by *Fregata* during her exploratory or experimental cruises to the areas. Practical fishing days by this method totaled 60 from eight cruises made during 1968 and 1969. *Alcyon* experimented with this method for 2 days on the shelf east of Central America during a production cruise to the area in June 1968.

DISCUSSION

Handline and Mechanical Reel Fishing

Catch

A total of about 291,000 pounds (round weight) of fish was taken by this method during these explorations. The catch and fishing effort, area, and period of individual cruises for each vessel for the entire period are shown in Table 1. The major groups in total catch by weight were: snapper of various species 51.4 percent, jacks 33.8 percent, grouper 5.9 percent, and other miscellaneous species 8.9 percent. Total fishing effort expended was about 19,901 line-hours (a typical line is a handline or mechanical reel line with three hooks) obtained during 3,460 hours in 382 days of actual fishing including simulated production cruises.

The overall average catch rate was 760 pounds of fish per day from 9.8 fishing hours with 5.3 lines, which equalled 146 pounds per line. These rates include both pure exploration and simulated commercial-type production fishing. The catch rate, fishing effort, and composition of catch (percent in weight) by main fish groups, by area of each bank or shelf are shown in Table 2.

Species

More than 70 species representing 15 families were caught on handlines and reels. The most important of these are members of the snapper (Lutjanidae), jack (Carangidae), and grouper (Serranidae) families. Table 3 lists the most important species caught.

The principal varieties of snapper were black, blackfin, and silk snapper along the shelf edge, and yellowtail and smaller sizes of blackfin snapper on the continental shelf in the northern region of the Caribbean; blackfin, queen, and silk snapper in the Windward Islands area; and Caribbean red snappers, vermillion snappers, and lane snappers off northeastern South America.

Jacks are usually considered pelagic fishes, but they were often caught on snapper handlines or reels. Best jack catches were on the eastern margins of the Nicaraguan shelf. The dominant species captured during all seasons were green jack by number, and horse-eye jack by weight. Considerable numbers of rainbow runner and amber jack were also taken seasonally. Black jack was the dominant species of the group on offshore banks in the area between south of Jamaica and the Leeward Islands. Amber and almaco jacks (sometimes recorded as one species) and horse-eye jack, although common, were not taken in quantity.

Grouper catches were generally light but added significantly to the totals. Hinds and yellowfin groupers were the main species of grouper on ragged hard bottoms in the northern region of the Caribbean. Nassau, red, yellowfin, and misty groupers were also common species in the eastern part of the Greater Antilles and in the Leeward Islands areas. Yellowedge, snowy, and Warsaw groupers were prevalent species of groupers only in the southern region of the Caribbean from north of Venezuela to French Guiana.

Grunts and triggerfishes formed most of the remaining group, in addition to the rainbow runner which is included in the "other" group in our recordings.

Average weight of fish for all species was 3.3 pounds each, being 3.0 pounds for snapper, 3.9 pounds for jacks, 5.0 pounds for grouper, and 2.6 pounds for other species.

Gear efficiency

Comparisons were made as to the amount of time required for one cycle

of handlining, mechanical reel, and electric reel fishing. The operation consisted of baiting (three hooks), lowering the line, hooking the fish, retrieving the line, and removing the fish. These observations were made in 60 fathoms of water under relatively good baiting conditions. The average total elapsed time was 4.7 minutes for the handline, 4.3 minutes for the mechanical reel (4.0 minutes when operated by two men), and 4.7 minutes for the electric-powered reel. Thus it can be calculated that when using handline or electric reels a maximum of 13 hauls per hour is possible or 14 hauls for one man on a mechanical reel. This is theoretical however, since line breakage, tangling, and other factors tend to reduce this figure to about 10 hauls per hour with each type of mechanical gear.

Of the two different types of hooks used, straight shank or tuna circle, each had advantages and disadvantages. Tuna circle hooks, shaped to resist escapement, were better for catching more fish in one haul, hence they were good for deeper bottom, but had some disadvantages in unhooking fish (for larger fish) and baiting (for small hook). The straight shank hooks (O'Shaugnessy) seemed better for hooking fish or bait, but allowed easy escapement of fish under water, hence this type of hook was mostly used only in shallow water. Small hooks produced a greater variety of fish such as vermillion snapper or triggerfishes which are often regarded as troublesome bait stealers.

Squid was the best bait for both catching fish and remaining longer on the hook. Some fishermen switched to mackerel bait, however, when squid produced few fish. Other baits like herring, shark, and sprats were poor in catching fish and/or staying on the hook.

Catch rate and fishing efficiency

Based on the hauling cycle limitation previously noted, under ideal conditions, the maximum theoretical catch rate obtainable is estimated to be about 40 fish/line/hour (at 3 hooks/line). Under average practical conditions this falls to about 15 to 20 fish / line / hour. Since the average weight of fish caught was 3.3 pounds (Table 1) the catch rate in weight for the latter becomes about 50 to 66 pounds / line / hour, considering the deviations caused by differences of depth, fish size, or fishing performance (fish biting hours). Table 4 shows some

Table 3.—Common name, scientific name, and some local names of fish caught by handline or reel methods.

Common name	Scientific name	Local name
(Snappers)	(Lutjanidae)	
Black snapper	*Apsilus dentatus*	Deep-sea snapper (JA)* chopa negra (P.R.)
Blackfin snapper	*Lutjanus buccanella*	Burnt-fin snapper (JA) negra (P.R.)
Dog snapper	*L. jocu*	Dogteeth snapper (JA)
Gray snapper	*L. griseus*	Caranjito (Pa.)
Lane snapper	*L. synagris*	Walliacke (Tr.)
Mahogany snapper	*L. mahogoni*	
Mutton snapper	*L. analis*	
Queen snapper	*Etelis oculatus*	Satin snapper (JA) Brim (Le)
Red snap. (Carib.)	*L. purpueus*	Pargo (Pa.)
Silk snapper	*L. vivanus*	Yelloweye (W.I.) Chillo (P.R.)
Schoolmaster	*L. apodus*	
Vermillion snapper	*Rhomboplites aurorubens*	
Volaz	*Pristipomoides macrophthalmus*	Deep-sea wenchman (JA)
Yellowtail snapper	*Ocyurus chrysurus*	Colirrubia (P.R.)
(Jacks)	(Carangidae)	
African pompano	*Alectis crinitus*	Silver jack (JA)
Almaco jack	*Seriola rivoliana*	Amberjack, medregal (P.R.)
Greater amberjack	*Seriola dumerili*	Medregal (P.R.)
Bar jack	*Caranx ruber*	Cojinuda (P.R.)
Black jack	*C. lugubris*	Jurel negron (P.R.)
Crevalle jack	*C. hippos*	
Green jack	*C. crysos*	Blue runner (W.I.)
Horse-eye jack	*C. latus*	Jurel ojon, cojobeo (P.R.)
Yellow jack	*C. bartholomaei*	
Rainbow runner	*Elagatis bipinnulata*	Salmon (JA) Tabio (B'dos)
(Groupers)	(Serranidae)	
Black grouper	*Mycteroperca bonaci*	Djanpau (Pa.)
Marbled grouper	*Dermatolepis inermis*	
Scamp or grey manock	*Mycteroperca phenax*	
Tiger grouper	*M. tigris*	
Yellowfin grouper	*M. venenosa*	Guajil (P.R.)
Yellowmouth grouper	*M. interstitialis*	
Jewfish	*Epinephelus itajara*	
Misty or moustache grouper	*E. mystacinus*	Guasa (P.R.)
Nassau grouper	*E. striatus*	Cherna (P.R.) Jacupepu (Pa.)
Red grouper	*E. morio*	Meru (Pa.) Vieille rouge (Tr.)
Snowy grouper	*E. niveatus*	
Warsaw grouper	*E. nigritus*	
Yellowedge or white grouper	*E. flavolimbatus*	
Coney	*Cephalopholis fulvua*	Manteguills (P.R.) Butterfish (JA) Purunchipretulfa (Le)
Red hind	*Epinephelus guttatus*	Cabrilla (P.R.)
Rock or speckled hind	*E. adscensionis*	
(Grunts)	(Pomadasyidae)	
Cottonwick	*Haemulon melanurum*	
Margate	*H. album*	Viuda (P.R.)
White grunt	*H. plumieri*	Cachicata, boquicolorado (P.R.)
(Others)		
Jolthead porgy	*Calamus bajonado*	
(Squirrelfishes)	(Holocentridae)	
Longspine squirrelfish	*Holocentrus rufus*	Gallo, candilero (P.R.) welchman (JA), (Le)
Ocean triggerfish	*Balistes vetula*	Oldwife (W.I.) Puerco (P.R.)
Sand tilefish	*Malacanthus plumieri*	Sandfish or sandeel (W.I.) jolocho (P.R.)
Blackline tilefish	*Caulolatilus cyanops*	
Moray eels	*Gymnothorax* spp.	
Sharks	*Carcharhinus* spp. *Negaprion* sp. *Sphyrna* sp. *Eulamia* sp.	

*(JA) — Jamaica, (P.R.) — Puerto Rico, (Le) British Leeward Is., (Pa.) — Papiamento, (Tr.) — Trinidad, (B'dos) — Barbados, and (W.I.) — West Indies.

short-time catch rates recorded on relatively good fishing grounds where fish schools were found on the echo sounder. Such short-time catch rates, however, are highly variable during the course of a day due to change of fish biting condition, difference of the vessel's passing duration over the fish school if drifting, change of current and/or wind, or sometimes a reduction of stamina of the crew.

Day catch rates for the best catches from principal banks or shelves during the explorations of the three project vessels are shown in Table 5. The catch rate in terms of numbers of fish ranges from 3.3 to 20.1 fish/line/hour with relatively longer biting durations. The catch rate in terms of weights has a wider range, from 10 to 137 pounds/line/hour depending on the size of fish available in the area.

Average catch rates from total fishing effort in Table 2 are far below the above figures since geographic and seasonal abundance are involved.

The catch rate from this type of fishing method would vary not only with the skill of the skipper, as in bottom trawling or purse seining, but also depend greatly on individual teachnique and incentives to the fishermen. To illustrate this, the fishing efficiency of the project vessel's crew and trainees, who engaged on the fishing cruises without bonus (except fixed sea allowance), is compared in Table 6 with catch rates of the local commercial fishermen who worked with them but upon a contract of full share-pay from their catch during the simulated production cruises. As footnoted in the table, there were some handicaps to the commercial fishermen in fishing methods and gear in the early cruises, but those were evened out in the later cruises. The technical ability of the commercial fishermen who were from the most skillful and experienced group of fishermen in Jamaica, was of course higher than that of the trainees, who undertook more than one-half of the *Alcyon's* fishing efforts. Trainees were replaced every 6 months at the termination of their course.

It is assumed, therefore, that project vessel catch rates during production fishing would be about 15 percent less than that of a commercial vessel having an experienced crew.

Discussion of fishing grounds by area

The average catch rate and catch composition by principal groups of species for all reel fishing efforts appear in Table 2. While this is of overall general interest, more specific information relative to fishing grounds, fish species, and season are necessary to select the best areas and seasons for carrying out commercial operations. These data are presented in tabular form with accompanying narrative for the following geographical areas and subareas in the Appendix:

(1) Jamaica south to southwestern waters of project area:

(a) South coast—Jamaica.

(b) Offshore south of Jamaica.

Table 4.—Selected short-time catch rates (average from five reels).

Date	Fishing grounds	Depth (fm)	Duration (hrs)	Actual no	Catch (lbs)	Catch rate no/hr	Catch rate lb/hr
20-3-68	Monte Cristi Bk. (N. edge)	30-40	1.25	82	417	11.8	60
21-3-68	Monte Cristi Bk. (N. edge)	35-40	0.5	50	257	20.0	102
19-3-68	Monte Cristi Bk. (WSW edge)	35-120	2.5	98	421	7.8	34
20-3-68	Monte Cristi Bk. (WSW edge)	50-120	2.0	44	202	4.4	20
26-3-68	Navidad Bank (NNE edge)	55-60	1.0	46	225	9.2	45
26-3-68	Navidad Bank (NNE edge)	55-60	1.2	61	264	10.2	44
27-3-68	Navidad Bank (NNE edge)	45-90	1.2	109	366	18.2	61
27-3-68	Navidad Bank (NNE edge)	45-90	1.5	84	301	11.2	40

Table 5.—Catch rates observed from the best catches on the best fishing grounds.

Area	Date	Total catch no	Total catch lbs	Total fishing (hrs)	Depth (fm)	Main species	Catch rate (-/line/hr) no	Catch rate (-/line/hr) lbs
E of Nicaragua	13-6-68	1,278	3,984[1]	18.7	18-24	HEJ, GRJ[2]	20.0	62
	24-6-69	1,204	3,328	10.4	18-24	GRJ, HEJ	20.1	56
	17-8-70	1,233	3,734[1]	9.0	22	YTS, GRJ	13.1	40
E of Honduras (2nd shelf)	13-8-70	743	909[1]	9.1	20	YTS	8.4	10
	15-2-68	263	1,113	10.0	28-120	BKS, YTS	3.3	14
Rosalind Bk.	1-7-67	300	664	4.2	22	YTS	9.5	21
	10-2-68	142	677	7.6	50-55	BKS, BFS	3.4	16
Alice Shoal	24-2-68	244	1,018	4.4	40-100	BKS, BFS	10.1	45
Pedro Bank (E)	23-7-69	219	896	10.0	35-130	BKS, SKS	3.7	15
Pedro Bank (SW)	24-6-67	584	1,174	5.3	14-30	YTS	15.7	32
Pedro Bank (NW)	13-8-69	461	1,775	9.7	40-80	BKS	7.9	31
Monte Cristi Bk.	20-3-68	278	1,428	5.5	50-120	BKS	10.1	52
Navidad Bank	26-3-68	611	2,305	12.3	50-60	BKS, BFS	11.0	42
Silver Bank	25-3-68	376	1,437	10.1	45-150	SKS, BKS	7.4	29
Virgin Islands (Barracuda Bk.)	15-4-69	364	1,542	9.3	35-60	BKS	7.8	33
Anguilla Bk.	8-4-68	376	1,969	12.2	50-120	BFS, BKS	6.2	32
Barbuda Bk.	30-10-68	293	1,237	8.2	35-125	SKS	7.1	30
Trinidad & Tobago	5-12-70	105	406	2.1	60-70	CRS	8.3	32
Guyana (N)	14-11-69	754	5,041	10.6	34	CRS	14.2	95
	12-12-70	395	3,901	4.3	41	CRS	13.9	137
	13-12-70	550	3,770	3.6	33-41	CRS	19.1	131
Surinam	20-8-69	374	1,076	10.0	37	CRS	7.5	22
	5-10-69	138	758	4.5	37	CRS	6.1	34
French Guiana (NE)	14-10-69	312	1,870	9.5	43	CRS	6.6	39
French Guiana (E)	16-10-70	313	1,391	10.7	52-63	CRS, VMS	4.9	22

[1]Production fishing cruise, but commercial fishermen's catch is excluded.
[2]HEJ = Horse-eye jack, GRJ = Green jack, YTS = Yellowtail snapper, BKS = Black snapper, BFS = Blackfin snapper, SKS = Silk snapper, CRS = Caribbean red snapper, and VMS = Vermillion snapper.

Table 6.—Catch rate comparison of crew, trainees, and commercial fishermen.

Cruise	Crew and trainees (lbs/line/hr)		Commercial fishermen (lbs/man/hr)[1]	
67-3[10]	7.8	(37)[2]	20.9	(100)[2]
68-4[4]	225.2	(121)	20.9	(100)[2]
68-5	46.0	(202)	22.8	(100)[2]
68-5[9]	16.7	(57)	29.1	(100)[2]
69-5,6[1]	8.9	(106)	8.4	(100)[2]
69-5[4]	18.0	(78)	23.1	(100)[2]
70-5[8]	20.4	(66)	30.8	(100)[2]
70-5[9]	18.7	(85)	22.0	(100)[2]
70-5[10]	27.0	(80)	33.8	(100)[2]
Total (average)	17.7	(78)	22.6	(100)[2]

[1]The fishermen occasionally used two lines at a time for one man and the catch rate includes the total catch from the two lines as lb/man/hr.
[2]Index. Commercial fishermen's catch rate = 100.
[3]Commercial fishermen fished mostly from satellite catcher boats in the night for yellowtail snapper in shallow waters while crew and trainees fished in daytime for deepwater snappers at edges.
[4]This cruise was the first experience for the commercial fishermen in catching numerous large-size jacks (10 lbs on average). The mechanical reels had the advantage for taking large-size fish while the commercial fishermen were discouraged because of sore fingers from their handlines from the heavy catch.
[5]Commercial fishermen fished most of the time from *Alcyon's* deck and also used mechanical reels whenever available.
[6]Mostly daytime fishing for deepwater snappers on slope edges.

(c) Banks southwest of Jamaica.
(d) Central American shelf.

(2) North of Hispaniola to Virgin Islands:
(a) Banks north of Hispaniola.
(b) Mona Passage.
(c) Puerto Rico and the Virgin Islands shelf.

(3) Leeward Islands:
(a) Sombrero Island—Anguilla Bank.
(b) Barbados—Antigua Bank.
(c) St. Kitts—Dominica.

(4) Windward Islands.
(5) Aves Island.
(6) Aruba—Curacao—Bonaire.
(7) Continental shelf of South America from Trinidad to French Guiana:
(a) Shelves around Tobago east of Trinidad.
(b) Shelves east of Orinoco River (lat.10°N to 9 °N).
(c) Shelves off Guyana.
(d) Shelves off Surinam.
(e) Shelves off French Guiana.

Bottom Longline Fishing

Catch

Only about 1,888 pounds (round weight) of fish was taken utilizing this method during the expeditions. Table 7 shows the catch, fishing effort, general area, and period by cruise.

Catch rate on average was only 3.3 pounds per basket (60 fathoms long with 15 to 16 hooks) or 19 pounds per 100 hooks from 87 sets in 58 fishing days. The catch by weight was about 15 percent (17 percent in number of fish) snapper, 21 percent (19 percent in number) grouper, 43 percent (25 percent in number) jack, and 21 percent (39 percent in number) shark and other fish. Chief species of these varieties are similar to those from the handline methods.

Discussion of bottom longline catch rate and gear efficiency

Catch rate and species composition by fishing area are shown in Table 8.

Soaking time ranged from 1.5 to 6.9 hours and averaged 3.1 hours. Results indicated that the catch rate did not increase with soaking time. Table 9 is a comparison of catch rates of each five sets between the longest and shortest soaking time. There was considerable bait loss, as evidenced by empty hooks, even during the sets of shortest duration. The "bait stealers" were not identified. Since snappers and jacks took baits soon after the lines reached bottom during handline operations, this feeding habit might be one of the reasons increased soaking time did not yield increased catches.

The catches deeper than 100 fathoms produced mostly sharks and a few moray eels. Best results were generally obtained from 30 to 80 fathoms.

As previously described the interval between each hook along a 60 fathom mainline was 4 fathoms, but 2-fathom intervals were used during the first two cruises on the Aruba and Bonaire shelves. A comparison of catch rates between the two different intervals of branchlines is shown in Table 10. The result is inconclusive due to the inequality of season and depths fished. Probable factors affecting these two different intervals are that snapper schools are generally compact and narrow while the groupers or jacks in these areas usually are well dispersed.

Fishing grounds

Catches and catch rates (pounds/basket) by fishing subarea and month are summarized in Table 11. Only the shelf edges off Tobago show relatively high catch rates, but even these amounts indicate bottom longlining is not as efficient as reel handlining.

Results of experimental bottom longline operations by Japanese in the Leeward Islands area also indicate the relative inefficiency of this gear for snapper. Their efforts produced a total of 2,533 pounds of fish (1,057 pounds of snappers) in six fishing days on Saba Bank using a total of 38,555 hooks (348 baskets) for 25 sets. The catch rate was only 6.6 pounds per 100 hooks with a range of 3.3 to 9.5. Their daily set ranged from 20 baskets (2,200 hooks) to 66 baskets (7,260 hooks) on 14 to 154 fathoms bottom.

DISCUSSION OF RESULTS AS RELATED TO COMMERCIAL POTENTIAL OF UNUTILIZED OR UNDERUTILIZED STOCKS OF SNAPPER AND RELATED SPECIES

Since most of the un- or underexploited areas exist beyond the range of the present local fishing boats, these boats cannot be expected to utilize the potential stock unless their size and their crews' technical know-

Table 7.—Fishing log—bottom longline fishing cruises for snapper and related species.

Fregata Cruise no	Month	Date	Area covered	Bottom longline fishing days	Fishing effort sets	baskets	hooks	Total Catch no	lbs	Snappers no	lbs	Groupers no	lbs	Jacks no	lbs	Others no	lbs
68-1	Jan. Feb.	9-26 12-	Aruba Bonaire	7	11	74	2,115	70	508	8	25	4	10	50	399	8 (5 sharks = 63 pounds)	74
68-2	Mar. Mar.	- 4 29-	(Klein Bonaire)	2	5	19	570	13	63	2	36	8	20	1	3	2	4
68-3	Apr. Aug.	-26 12-	Barbados	10	11	110	1,760	29	107	2	4	6	4	3	19	18	80
68-7	Sep.	-20	Trinidad & Tobago	11	19	175	2,663	152	817	27	91	35	229	38	332	52	165
69-1	Jan. Feb.	8-25 14-	St. Lucia - St. Vincent	7	10	59	944	44	66	9	29			1	5	34	32
69-2	Mar.	- 7	Grenadine Is.	6	10	41	656	41	187	7	26	12	104	3	37	19	20
69-3	Mar. May	17-29 20-	Barbados	7	12	44	704	12	69 (+?)	7	61	1	4	1	4	3	?
69-5	July	- 5	Aruba-Bonaire	8	9	42	568	24	22 (+?)	2	5	6	17 (+?)	—	—	16	?
8 cruises			Total	58	87	564	9,980	385	1,839 (+?)	64	277	72	388 (+?)	97	799	152	375 (+?)

Table 8.—Bottom longline catch rate by area.

Fishing area	Catch rate lb/100 hooks	Catch rate fish/100 hooks	Catch composition (% in wt) Snap.	Jacks	Group.	Shark	Others	Total hooks	Depth ran (fathoms)
St. Lucia shelf	10.2	2.7	46	16	10	0	28	300 (20)*	18-110
St. Vincent shelf	11.8	7.5	38	0	16	35	11	360 (24)	30- 45
Grenadine Is. shelf	7.7	3.8	48	0	49	3	0	873 (57)	17-210
Near Tobago	39.3	5.7	10	36	36	10	8	2,211 (149)	21-148
SE offshore Tobago	16.2	5.1	22	41	2	34	2	396 (24)	18- 56
Near Trinidad	6.9	5.9	19	0	35	38	8	375 (25)	25- 35
Barbados shelf	8.2	2.4	36	19	4	38	3	2,480 (158)	28-255
Aruba shelf	21.2	3.2	5	77	3	12	3	2,435 (94)	27-152
Bonaire shelf	15.9	3.1	29	2	20	32	17	902 (41)	18-195

*Number of baskets.

Table 9.—Catch rates by soaking time.

Soaking time (hr)	Catch rate (fish/100 hooks)	Total hooks
Longest soaking time		
6.9	0	160
6.3	0.6	160
5.2	0.6	160
4.9	0	60
4.5	3.1	120
Shortest soaking time		
1.5	9.2	120
1.6	6.7	75
1.7	1.3	75
1.7	9.2	120
1.8	8.3	60

ledge of navigation and modern fishing methods are increased. Economically, an appropriate size boat would be between 45 and 60 feet long depending on the cruising range from its base.

As indicated in the Appendix, the areas with the greatest potential for commercial fishing operations are east of Nicaragua, Navidad Bank, Barracuda Bank, Anguilla Bank, and the Guyana shelf.

The use of a mothership type operation, taking one or two small satellite boats, has considerable potential. The advantage of the mothership type operation is a remarkable increase in catch at a lesser increase in the cost of production. This type of operation, however, is restricted by sea conditions for the satellite boat. From the experience of the project vessels, these boats of 17 to 19 feet, open dory type, could not go fishing from the mothership when the wind exceeds Beaufort scale 3. Since the trade winds in the Caribbean area often blow continuously with more force, this type of operation may be possible only during part of the year.

A possible deterrent to the expansion of the fishery for snapper, grouper, and jacks in the northern Leeward Islands and adjacent banks is the fact that individual fish from these groups may be occasionally ciguatoxic and, therefore, cause ciguatera fish poisoning when eaten by man.

According to Halstead (1970), there is a growing amount of evidence to suggest that the largest populations of toxic fish are found within the Virgin and Leeward islands, with the epicenter at the St. Kitts-St. Eustatius-Redonda Island complex. Historically certain species, such as yellowfin groupers, dog-tooth snappers, and horse-eye jacks, over a certain size (about 2 kilograms) from specific localities have been considered suspect. Accordingly these species, as well as others, are avoided by commercial fishermen, and if caught they are discarded. After fish caught by one of the project vessels reportedly caused ciguatera poisoning it became project policy to save, for research purposes, demersal species caught in the northeastern portion of the Caribbean, rather than sell them. An exception was silk snapper, since this species usually inhabits depths from 60 to 100 fathoms, and fish caught at these depths are less frequently ciguatoxic than those from shallower waters. No cases of ciguatera were reported from the silk snapper sold. At the present time a ciguatera studies project is being carried out by the Caribbean Research Institute at the College of the Virgin Islands. The laboratory facilities for the project are located at Benner Bay, St. Thomas, Virgin Islands.

It should be clearly understood that the catches of snapper, jacks, and groupers from the banks southwest of Jamaica, north of Hispaniola, and off the northeast coast of South America contained no ciguatoxic fish, and the development of the great latent fishery resources these groups represent should not be overlooked because ciguatera is associated with these groups in the northern Leeward Islands and adjacent banks.

CONCLUSIONS

Considering the results obtained from 5 years of exploratory fishing, the project has concluded that the resource of demersal snappers and related species in the Caribbean and adjacent waters could support increased annual production by utilizing presently under- or unexploited grounds. Based on the estimate of 20,000 to 25,000 tons presently taken yearly from the region by local fishermen on local grounds this increase could be two to four fold based on estimates of Carpenter and Nelson (1968) and of Gulland (1970).

The handline (electric reel) fishing method has produced profitable catch rates from a number of locations throughout the region. It is selective towards larger fish and therefore does not catch some species having only small size ranges. The bottom longline fishing method has not demonstrated commercial potential.

Table 10.—Catch rate comparison at 2 and 4 fathom hook intervals.

	Around Bonaire fish/basket	Around Bonaire fish/100 hooks	Aruba NW shelf fish/basket	Aruba NW shelf fish/100 hooks
30 hooks/basket (2 fathom intervals)	0.7	[1]3.2	1.1	[3]3.6
15 hooks/basket (4 fathom intervals)	3.6	[2]24.2	0.5	[4]2.8

[1]March 1968, 5 sets (570 hooks — 19 baskets) on 18-105 fathom bottoms.
[2]May and June 1969, 4 sets (269 hooks — 18 baskets) on 65-195 fathom bottoms.
[3]January 1968, 9 sets (1,815 hooks — 62 baskets) on 27-110 fathom bottoms.
[4]June 1969, 4 sets (320 hooks — 20 baskets) on 96-152 fathom bottoms.

Table 11.—Bottom longline catch rates by subareas.

Fishing ground	Month	Total set (baskets-hooks)	Depth range (fm)	Catch rate (lb/basket)	Catch by Species			
					Snapper	Jack	Grouper	Others
St. Lucia shelf								
N to NW side	Jan. 1969	2 (12-180)	30- 110	2.5	3 (14)	1 (5)	2 (3)	2 (9)
South side	Jan. 1969	1 (8-120)	18	0	0	0	0	0
St. Vincent shelf								
West side	Jan. 1969	1 (8-120)	30- 40	3.3	0	0	6 (7)	5 (19)
S to SE side	Jan. 1969	2 (16-240)	30- 45	1.4	4 (16)	0	6 (?)	4 (-)
Grenadine Is. shelf								
S to SW of Bequia	Jan. 1969	2 (10-150)	21- 39	0.7	1 (4)	0	5 (3)	0
West of Quatre	Jan. 1969	1 (5- 75)	17- 19	1.4	1 (4)	0	2 (3)	2 (-)
NE of Sail Rock	Jan. 1969	1 (5- 75)	27	0	lost gear			
NE of Carriacou	Feb. 1969	1 (10-160)	45	0	0	0	0	0
N to NE of Grenada	Feb. 1969	3 (17-259)	17- 27	3.0	4 (24)	0	16 (27)	0
S to SW of Grenada	Feb. 1969	2 (10-154)	196-210	0.2	2 (2)	0	0	2 (2)
Tobago								
East side	Sep. 1968	5 (50-763)	43- 78	9.5	6 (39)	18 (138)	23 (196)	13 (103)
East side	Feb. 1969	6 (23-319)	42-148	6.0	4 (3)	3 (37)	11 (95)	0 (25)
N to NE side	Sep. 1968	6 (58-869)	33- 60	1.9	9 (23)	5 (40)	5 (20)	10 (25)
SW side	Sep. 1968	1 (8-108)	30	16.1	1 (11)	8 (95)	0	5 (23)
SE side	Sep. 1968	1 (10-152)	21- 25	1.8	1 (9)	0	0	2 (9)
Off-shore SE of Tobago	Sep. 1968	3 (24-396)	18- 56	2.7	6 (14)	2 (26)	1 (1)	11 (23)
Trinidad N & NE side	Sep. 1968	3 (25-375)	25- 35	1.0	4 (5)	0	5 (9)	13 (12)
Barbados shelf								
South side	Mar. 1968	10 (100-1,600)	42-210	1.0	2 (4)	2 (16)	6 (4)	18 (80)
South side	Mar. 1969	5 (20-300)	28- 87	4.6	8 (70)	4 (20)	1 (-)	1 (2)
West side	Mar. 1968	1 (10-160)	57- 38	0.3	0	1 (3)	0	0
West side	Mar. 1969	4 (16-240)	60-195	?	0	0	0	6 (?)
N to NW side	Mar. 1969	3 (12-180)	75-255	0.3	0	0	1 (4)	7 (?)
Aruba								
NW side	Jan. 1968	9 (62-1,815) *	27-110	8.0	6 (24)	48 (389)	4 (10)	8 (74)
NW side	June 1969	4 (20-320)	96-152	0.4	0	0	5 (8)	4 (?)
SE side	Jan. 1968	2 (12-300)	29- 63	0.9	2 (1)	2 (10)	0	0
Around Klein Bonaire	Mar. 1968	5 (19-570) *	18-105	3.3	2 (36)	1 (3)	8 (20)	2 (4)
Bonaire Klein Bonaire	May-Jun. 1969	4 (18-269)	65-195	4.4	2 (5)	0	1 (9)	12 (66)
East tip	May 1969	1 (4- 63)	45- 60	0	0	0	0	0

*25 to 30 hooks per basket.

Ciguatera will remain a deterrent to expansion of the snapper, grouper, and jack fishery in the northern Leeward Islands, but research efforts are underway to overcome this problem.

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APPENDIX

Jamaica South to Southwestern Waters (Fig. A-1)

South coast of Jamaica

Within reach of local fishing vessels out of Kingston Harbor, more than one dozen offshore banks exist. These have already been heavily exploited by effective fish traps and handlines. In July 1967 and January and August 1969 experimental fishing was carried out to effect comparisons with efforts in unexploited areas. As indicated in Table A-1, poor fishing results were obtained.

Offshore south of Jamaica

As anticipated, offshore banks which are within the operational range of only the larger local boats produced much better results. Mackerel Bank comprises two separate banks which lie about 25 miles south of Kingston. The total area is 11.5 square miles with a total circumference of about 21 miles.[3] A few fishermen from Port Royal or from Old Harbor set pots or do handlining there. The nearest part of Pedro Bank, the northeast edge, is about 50 miles from Kingston. It extends westward about 100 miles, has a total area of about 2,365 square miles, and a total circumference of nearly 319 miles. The eastern shelf around the cays on the bank has been extensively exploited by pot fishermen based on the cays serviced by carrier vessels. The mid-part of the north side is being fished by some larger canoes from the southwest coast of Jamaica during good weather. The remaining area is fished very little.

Three unnamed banks about 35 miles southeast of Morant Cay are seldom fished and have a total area of 36.5 square miles with 44 miles circumference. Catch rates for specific locations in the offshore waters south of Jamaica are given in Table A-2.

The catch rate from Mackerel Bank ranged from 12.4 pounds/line/hour in January to 4.0 pounds/line/hour in

[3] All miles in this paper are nautical miles.

July. The best catches occurred from 35 to 45 fathoms on the southeastern edge. Black snapper comprised 66 percent of the total catch. Most black snappers were feeding heavily on *Clavelina* (a species of tunicate called "Sea Tapioca" by Gulf of Mexico snapper fishermen). Snapper from other productive banks (Silver, Navidad, etc.) were also feeding heavily on Sea Tapioca. Black jack and hinds were the next dominant species in the area. On one occasion a school of rainbow runners congregated around the vessel and 56 fish (278 pounds) were captured in 2 hours. From this area, during the production cruise in January 1969, the commercial fishermen aboard averaged 99 pounds/man/day during 6 days fishing.

The catch rate of deepwater snapper in daytime on the eastern edges of Pedro Bank from Portland Rock to the southeast tip of the bank ranged from 3 to 17 pounds/line/hour. The catch rate from the commercial fishermen aboard a satellite catcher boat at night in shallower waters was 136 pounds per 9 hours fishing per man. This was mostly yellowtail. Black, followed by blackfin and silk, snapper dominated catches from the slope edge from 35 to 80 fathoms, with volaz (deep sea wenchman) dominating from 80 to 130 fathoms. Black jack, horse-eye jack, yellowfin grouper, hinds, grunts, and triggerfish were common, but did not collectively comprise more than 30 percent of the total catch by weight. Fishing along the south edges of Pedro Bank resulted in catches ranging from only 1.2 to 3.0 pounds/line/hour. The species caught were similar to those from the east edges. The shelf southwest of NW Ridge was relatively productive for yellowtail snapper. The daily catch rate ranged from 6.6 to 31.6 pounds/line/hour in June 1967 (83 percent yellowtail). Catches ranged from 2.1 to 14.9 pounds/line/hour in November 1967 (45 percent yellowtail). The lower catch rate and percentage of yellowtail was due to the project vessel fishing more for deepwater snapper: silk, black, and blackfin. The satellite boat with commercial fishermen produced fish in 14-16 fathoms at a rate of 223 pounds (66 percent yellowtail)/man/day for 10 days fishing. In December 1968 and August 1969 a few days fishing for yellowtail and deepwater snappers near the southwest tip of the bank resulted in poorer catch rates—1 to 9.7 pounds/line/hour.

Figure A-1.—Area of operations—Jamaica south to southwestern waters.

Table A-1.—Catch rates observed at specific locations off south coast of Jamaica.

Fishing ground	Month	Depth range fished (fm)	Hours fished	Catch rate (lb/line/hr)
New Bank	Jan. 1969	60-100	4.7	0.2
Blossom Bank	Jan. 1969	25-110	3.8	0.5
Cow Bay	Aug. 1969	50-110	1.2	0
Lamottes Bank	Aug. 1969	40-80	2.8	0
Norseman Bank Dingle Bk. & Morant Pt.	Aug. 1969	40-140	6.6	0
California Bank	Jan. 1969	35-90	6	2.0
California Bank	Aug. 1969	30	4	2.0
Walton Bank	July 1967	20-50	3.4	0.3

Fishing operations on the western edges of the bank northward from the southwest tip resulted in rather poor catch rates. In February 1968, 117 silk snappers (200 pounds) were caught from 100 to 120 fathoms in one day. In August only 10 silks (23 pounds) were caught along with a few blackfin snapper, black snapper, amberjacks, horse-eye and black jacks, yellowfin grouper, and hinds. High catch rates of 30.5 and 25.4 pounds/line/hour (85 percent black snapper) were obtained in 40 fathoms from the northwest tip of the bank in August 1969.

The three unnamed banks southeast of Morant Cays were fished for one-half day in July 1967, one day in July 1969, and three days in October 1967. The catch rates resulted in 11.6, 3.1, and 4.8 pounds/line/hour, respectively. The dominant species were black snapper, black jack, and some groupers. Waves from a relatively strong current and wind along the edges of the banks hampered efforts to keep appropriate depths on the rather steep slope edges in the area. A small bank 13 miles west of Morant Cay was fished by handline at depths of 18 to 35 fathoms for three nights and two days during a pot fishing cruise in July 1970. The catch rate was about 4.1 pounds/line/hour. The species caught were similar to those from the three unnamed banks above.

There are several banks east of Jamaica, namely Formigas Bank, Grappler Bank, Henry Holmes Bank, Albatross Bank, and Decca Ridge, in order from north to south, but being within reach of the local fishermen no efforts were expended there.

Table A-2.—Catch rates at specific locations—offshore south of Jamaica.

Fishing ground	Month	Depth range fished (fm)	Hours fished	Catch rate (lb/line/hr)	
Mackerel Bank	Jan. 1969	25-85	48.5	12.4	(16.6)**
Mackerel Bank	July 1969	30-120	14.0	4.0	
Three banks southeast of Morant Cays	July 1967	40-80	2.5	11.6	
	July 1969	35-130	8.5	3.1	
	Oct. 1967	18-150	13.9	4.8	
A bank west of Morant Cay	July 1970	18-35	(5 days)*	4.1	
Pedro Bank East of Portland Bank	Jan. 1969	12-110	28.3	6.6	(8.5)**
	June 1967	15-50	4.0	7.8	
	July 1969	40-135	5.0	3.6	
	Nov. 1967	13-130	127.6	7.7	(9.5)**
E. of Blower Bank	July 1969	35-130	10.0	14.9	
SE Tip	July 1970	30-40	(7 days)*	8.7	
Shanon Shoal	June 1967	20-40	14.7	2.6	
South of Banner Reef	Aug. 1969	60-100	1.0	3.0	
Southwest R'K	Aug. 1969	10	3.0	1.2	
South of NW Ridge	June 1969	14-35	84.2	11.5	
	Nov. 1967	11-60	109.5	7.2	(12.6)**
	Dec. 1968	18-40	2.5	3.0	
Southwest tip	Aug. 1969	10-100	23.8	4.1	
West edges	Feb. 1968	55-140	8.2	6.2	
	Aug. 1969	30-70	17.3	2.8	
Northwest tip	July 1967	15-50	7.8	1.8	
	Aug. 1969	28-80	24.2	23.4	

*Fished by landline gear mostly in the morning and evening during pot fishing cruise.
**Catch rate from the commercial fishermen aboard in pounds per line per hour

Table A-3.—Catch rates at specific locations on banks southwest of Jamaica.

Fishing ground	Month	Depth range fished (fm)	Hours fished	Catch rate (lb/line/hr)	
Alice Shoal	Feb. 1968	40-50	12.4	24.5	
	May 1968	28-30	8.0	3.7	(3.1)**
	Aug. 1968	14-100	54.6	6.0	
Rosalind Bk. east edge	Feb. 1968	26-140	20.7	6.4	
	May 1968	14-25	7.0	6.8	(18.7)*
	June 1969	30-60	1.0	4.4	
	July 1967	20-50	7.3	22.0	
	Dec. 1968	21-25	3.0	12.8	(11.7)*
West edge	Feb. 1968	45-110	7.6	16.2	
Banks between Thunder Knoll & Rosalind Bank	Feb. 1968	25-130	33.7	8.8	

*Catch rate of commercial fishermen aboard in lb/line/hr.

Banks southwest of Jamaica

Farther southwest of Jamaica, between 200 and 300 miles, is Alice Shoal (77 square miles with 33 miles circumference), Serranilla Bank (291 square miles with 75 miles circumference), Serrane Bank (105 square miles with 56 miles circumference), Rosalind Bank (1,441 square miles with 157 miles circumference), Thunder Knoll (49 square miles with 26 miles circumference), and a few unnamed banks (347 square miles and 93 miles circumference in total) between Rosalind Bank and Thunder Knoll. Of these, only the two banks on which some cays exist are being fished to some extent by the carrier-canoes type of operation previously mentioned. This leaves a tremendous area practically unfished and certainly offers good commercial potential (Table A-3).

On Alice Shoal, the northeastern part of the edge showed a catch rate ranging from 11.7 to 42.1 pounds/line/hour of black and blackfin snappers and black and horse-eye jacks in 32 to 100 fathoms during daytime. At night it was 3 to 9 pounds/line/hour for horse-eye jack, blackfin snapper, and hinds on the shallower bottom (14-28 fathoms). The catch rate on the south edge was 5.4 to 15.0 pounds/line/hour. The rest of the edges were poor in catch. Only four silk snappers (37 pounds) were caught on Alice Shoal. On Rosalind Bank, a good catch rate of yellowtail snapper at 21.1 pounds/line/hour was obtained from 22 fathoms on the northern part of the east edge in daytime. In February, May, December of 1968 and June of 1969 overnight fishing produced mostly yellowtail snapper and horse-eye jacks. One daytime fishing operation for deepwater snappers resulted in only 3.7 pounds/line/hour (mostly of silk snapper and some blackfin snapper) with the best catches at 120 fathoms. One daytime fishing operation on the west edge (lat.16°29'N) resulted in a 16.2 pounds/line/hour catch rate, the best depth being 50 to 55 fathoms for black snapper and 60 to 80 fathoms for blackfin snappers. During the production cruise the commercial fishermen fished in 14 to 25 fathoms at night only, with catch rates of 178 pounds/man/day in May 1968 and 88 pounds/man/day in December 1968.

In 45 to 130 fathoms on the northeast edge of the unnamed bank west of Rosalind Bank the catch rate was 18.5 pounds/line/hour of mostly silk snapper during daytime. Night catch rates on the shelf (25-58 fathoms) were less at 6.7 to 8.4 pounds/line/hour, chiefly for blackfin, yellowtail, and black snappers and horse-eye jack.

Central American shelf

The second shelf, connected by a narrow neck to the main continental shelf east of Honduras, and some shelf margins east of Central America are within 350 miles range from Kingston. The second shelf has an area of about 1,920 square miles with about 184 miles circumference. The Central American shelf from Pt. Blanca (about lat.10°N) northward to Cape Camarón (about long.85°W) has almost 29,000 square miles with 660 miles of shelf margin (excluding the second shelf). Exploratory fishing on and near the margin for snappers was extended to the area for overall evaluation of the fishing grounds in the Caribbean. The catches appear in Table A-4.

On the second shelf, night catch rates (from 14 nights' fishing in various months) in 18-40 fathoms along the edges ranged from 2.7 to 17.9 pounds/line/hour with an average of 8.2 pounds. Day catch rates (from six daytime operations) on the same shelf (20-34 fathoms) ranged from 4.3 to 12.2 pounds/line/hour with an average of 7.6 pounds. Dominant species were yellowtail snapper and horse-eye jack with traces of blackfin, dog, schoolmaster, and lane snappers, green and yellow jacks and amberjack, red and yellowfin groupers, hinds, triggerfish, white and margate grunts, and porgy. The productive area for yellowtail snappers on the shelf was around

Table A-4.—Catch rates at specific locations—Central American Shelf.

Fishing ground	Month	Depth range fished (fm)	Hours fished	Catch rate (lb/line/hr)	
Second shelf NE edge	Feb. 1968	20-25	10.5	4.8	
East edge	Feb. 1968	22-130	29.8	8.6	
South edges	Feb. 1968	22-130	56.8	14.8	
	Apr. 1969	24-90	32.0	6.7	(23.5)*
	May 1968	28-30	5.5	2.5	
	June 1969	24-34	4.1	7.9	
	Aug. 1970	20-32	41.4	8.2	(16.4)*
SW edge	Feb. 1968	18-120	21.7	10.4	
Main shelf edge from the neck to 15°N	Feb. 1968	21-110	20.8	8.6	
	Apr. 1969	40-80	3.0	1.6	
	May 1968	22-25	8.5	4.7	
Main shelf edge from 15°N to 14°30'N	Feb. 1968	28-120	17.3	20.7	(22.9)*
	Apr. 1969	16-90	101.4	22.6	(22.5)*
	May 1968	20-40	100.5	29.2	
	June 1968	18-70	57.5	46.0	(35.0)*
	June 1969	18-100	51.6	39.5	
	Aug. 1970	16-22	50.4	30.8	(41.5)*
	Sept. 1970	15-20	65.6	18.7	(22.0)*
	Oct. 1970	18-20	39.0	27.0	(33.8)*
	Dec. 1969	20-100	98.3	17.2	(35.6)*

*Catch rate from the commercial fishermen aboard in lb/line/hr.

lat. 15°16'N, long. 81°12'W to lat. 15°21'N, long. 81°28'W (20-30 fathoms). Catch rates for deepwater snappers along the edges ranged from 4.5 to 23.6 pounds/line/hour with an average of 12.5 pounds/line/hour from nine daytime efforts mostly in February 1968. On the east edges, silk and blackfin snappers and amberjack were dominant at 85 to 130 fathoms. Around the south point of the shelf where a few bottom slopes protruding into deep water exist, relatively high catch rates of black and blackfin snappers were obtained with traces of black jack and amberjack, margate grunts, red grouper, and hinds mixed. On the southwest edges of the shelf, Caribbean red snapper, silk, and blackfin snappers were captured from 60 to 120 fathoms at a rate of 23.6 pounds/line/hour. The commercial fishermen aboard produced fish, mostly yellowtail snapper, at a rate of 254 pounds (April) and 171 pounds (August)/man/day.

Along the edge of the main shelf, from the neck to the second shelf southward to lat. 14°15'N, yellowtail snapper, horse-eye jack, and green jack were abundant around ridges along the shelf edges. The best ground is located at about lat. 14°33'N, long. 81°45'W where a ridge running along the edge becomes highest (16 to 18 fathoms below the surface) and the edge line of the shelf is convex. Daily catch rates here ranged from 8.5 to 98.0 pounds/line/hour. Most were higher than 20 pounds/line/hour. Catch rates in daytime fishing averaged 39.9 pounds/line/hour with a range between 15.2 and 93.9, while nighttime catch rates on the same bottom were less at 24.6 pounds/line/hour, ranging from 8.6 to 52.2. The catch was composed mostly of horse-eye and green jacks and yellowtail snappers, but mutton snapper accounted for 70 to 81 percent of the snapper group in May and June (30 fathom bottom near the ridge) and some large amberjack (20 to 30 pounds size) occupied 15 to 21 percent of the jack group in April, May, and August (from 16 to 20 fathoms). Rainbow runners were caught seasonally from April to June, the amounts being from 7.7 percent to 16.5 percent of the total catch. This species was caught mostly near the surface at night by cast and pull type of operation with a line and baited hook. The commercial fishermen on board produced fish at 323 pounds/man/day on average from a total of 47 fishing days in this area, the range of the average catch rate by month being: April 1969—266, May 1968—234, June 1968—356, August 1970—517, September 1970—267, October 1970— 337, and December 1968—282. From the above location farther north to the neck of the second shelf or south about lat. 14°15'N, only a few places—lat. 15°19'N, 14°53' to 14°50'N near the shelf edge—had a catch rate of more than 20 pounds/line/hour for the shallow-water snapper and jacks.

The catch rates for deepwater snappers on the edge of the slope were relatively low, ranging from 1.6 to 25.3 pounds/line/hour. The edge of the slope around the foregoing convex shelf was the best ground for Caribbean red snappers and black snappers, but the average catch rate was only 12.4 pounds/line/hour for all species.

A strong northerly current which dominates this area often made handline fishing difficult because the boat was unable to hold the best fishing position. The period of biting of these shallow-water snappers and jack seemed to bear some relation to the current changes (direction and velocity) caused by the tidal current complex in the area. There were two phenomena to suggest this; one that either good or poor bites were often observed soon after some change of direction following a slack current event when echo soundings confirmed the existence of fish under the ship. The other reason is that with swinging of the vessel due to wind (east-northeasterly) and current (northerly), the nature of the bottom under the ship could change considerably during the fishing trial and different species of fish would be caught at different periods. It was observed that catches of grunts, hinds, or triggerfish would be made after initiating good bites by yellowtail snappers or jacks, or vice versa. Both phenomena were observed during successive fishing for several days by securing the vessel on the best spot by anchor with 90 to 120 fathoms of rope. Moon phase, which influences the tidal current, seemed to affect the night fishing by its brightness as well. Noticeable quantities of horse-eye jack and green jack were seen under the ship lights, and were caught by cast and pull type handlines on dark nights but not on full moon nights.

North of Hispaniola to Virgin Islands (Fig. A-2)

Banks north of Hispaniola

North of Hispaniola are three significant banks within 50 miles range of the coast. One is Monte Cristi Bank, which is an extended island shelf with an area of 309 square miles. The second is Silver Bank (868 square miles with 138 miles circumference) and the third is Navidad Bank (196 square miles with 73 miles circumference).

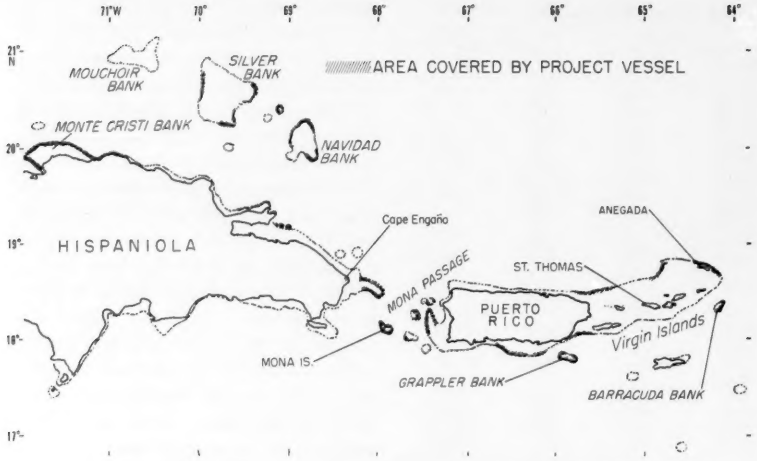

Figure A-2.—Area of operations—north of Hispaniola to Virgin Islands.

Three unnamed small banks exist between the latter two offshore banks, and one to the south of Silver Bank with a total area and circumference of 27.8 square miles and 34.5 miles, respectively. Catch results are given in Table A-5.

Catch rates on the west tip of the Monte Cristi Bank ranged between 6.5 and 20.9 pounds/line/hour, with over 60 percent of the total catch being black snapper. Silk snapper (10 to 20 percent), blackfin snapper (2 to 3 percent), vermillion snapper (1 to 2 percent), and queen snapper (0 to 30 percent) were common. Black, horse-eye, and amberjack or almaco jacks were also common, but collectively accounted for only 4 to 8 percent of the total catch. Nassau and red groupers, hinds, and grunts were the other varieties included in the total. The best depth range for snappers in this area was 60 to 70 fathoms (black snapper), 50 to 60 fathoms (blackfin snapper), 80 to 105 fathoms (silk snapper), 120 fathoms (vermillion snapper and volaz), and 114 to 130 fathoms (queen snapper). On the north edges of the bank only the western side showed better catch rates, from 3.5 to 51.7 pounds/hour, while the eastern side was unpromising. The dominant species in this area is black snapper (nearly 90 percent of the total catch). No queen or vermillion snapper was caught, but dog and mutton snappers were present. Silk, blackfin, and yellowtail snapper, amberjack, almaco, and horse-eye jacks, yellowfin and misty grouper, hinds, and grunts were also present in trace quantities. On these edges, black snappers were produced from shallower bottom (34 to 45 fathoms). On some occasions, black and blackfin snappers, horse-eye jacks, and triggerfish were caught in 10 to 15 fathoms near the surface over a 40 fathom bottom, being recorded on the echo sounder like a surface school of fish. Dog snappers were caught at 40 to 44 fathoms during daytime, but from 14 fathoms after dark. Mutton snappers were caught in 30 to 35 fathoms. Small size yellowtail snappers were caught from 30 to 54 fathoms.

A productive place on Silver Bank was the north side of the east tip around lat.20°39′N, long.69°22′W. On this edge, silk snapper was abundant at 80 to 110 fathoms while most black and blackfin snappers were found at 40 to 80 fathoms. Vermillion and queen snappers and volaz were included in snall quantities from waters over 100 fathoms. Common species of jacks and groupers were black jack, misty grouper, and hinds. On the shallow (12-16 fathoms) south and west edges, the only snapper caught were blackfin and yellowtail. Other varieties of fish caught on these shallow bottoms were Nassau, yellowfin, and tiger groupers; hinds; and grunts. The catch rates were low at 3.3 to 4.3 pounds/line/hour. One stop for 1.6 hours' fishing at southeast tip of the bank produced a high catch rate of 20.5 pounds/line/hour for mostly black snappers.

The edges along the north tip of the Navidad Bank were productive. The daily catch rates ranged from 58.7 to 165 pounds/line/hour. Dominant species were black and blackfin snappers and black jack. The explorations on these edges were made only in February 1969 and March 1968 and 1969. The following is a comparison of catch composition (percent in weight) for the main species. (Figures in parentheses are percent number of fish.)

	Feb. 1969	Mar. 1968	Mar. 1969
Black snapper	48.0 (41.3)	52.7 (45.6)	57.1 (46.6)
Blackfin snapper	33.6 (40.9)	25.1 (33.6)	24.3 (30.4)
Black jack	11.0 (9.9)	12.5 (11.7)	3.9 (3.3)
Groupers	2.3 (3.8)	1.1 (1.4)	9.3 (14.5)
Others	5.1 (4.1)	8.6 (7.7)	5.4 (5.2)

The average catch rate in March 1969 was less than half that of the same month of the previous year (16.1 pounds versus 36.3 pounds), but the catch composition for snappers shows

Table A-5.—Catch rates at specific locations—banks north of Hispaniola.

Fishing ground	Month	Depth range fished (fm)	Hours fished	Catch (lb/line/hr)
Monte Cristi Bank West edge	Feb. 1969	30-100	13.4	6.5
	Mar. 1968	25-120	31.8	20.9
North edge	Feb. 1968	30-100	6.6	2.8
	Mar. 1968	25-120	30.5	19.7
East half	Mar. 1968	42-120	9.4	1.6
Silver Bank				
East edge	Feb. 1969	40-80	14.2	13.1
East edge	Mar. 1968	45-150	10.1	28.5
Southern edge	Sept. 1967	12-14	20.6	3.3
SE tip	Feb. 1969	40-80	1.6	20.5
West edge	Sept. 1967	16	12.0	4.3
Navidad Bank				
South edge	Sept. 1967	14-40	17.5	8.9
North edge	Feb. 1969	40-80	33.5	32.3
	Mar. 1968	45-90	23.0	36.3
	Mar. 1969	25-80	34.0	16.1
A small Bank NW of Navidad Bank	Sept. 1967	15-18	15.0	2.7
Banks east of Samana Bay	Mar. 1968	52-100	4.5	7.0

almost the same ratio, the balance being affected mostly by the occurrence of black jack and groupers. A remarkable difference in fishing for the two March fishing operations was the depth occurrence of the snappers, the productive depth range for the 1968 cruise being from 50-60 fathoms while in 1969 it was shallower—30 to 50 fathoms. In February, the depth occurrence for the snapper was more like the previous March at 45 to 60 fathoms. Occasionally fishing effort at a certain depth affects the catch composition as well as catch rate but, since a drift for fishing is made from shallow to deep water (or vice versa according to current and wind direction), as long as fish biting continues the catch compositions by species and the depth occurrence given above can be regarded as representing the abundance of the good commercial species.

On the south edges of the bank, the catch rates on the shallow bottom from 14 to 40 fathoms near the edge resulted in 8.4 to 10.5 pounds/line/hour producing more groupers (yellowfin, hinds, Nassau, misty, etc.) than snappers (blackfin, silk, black, and yellowtail).

One day's fishing in 10 fathoms on one of the unnamed small banks resulted in a poor catch rate of 2.7 pounds/line/hour for the shallow bottom near the edges. Hinds and groupers occupied nearly 66 percent of the total catch, while snappers and jacks occupied 13 percent and 10 percent of the total, respectively.

One-half day coverage on the three small banks east of Samana Bay produced 157 pounds of fish, mostly black snappers, from a total of 4.5 hours fishing with five reels on various deep spots. The catch rate of 7.0 pounds/line/hour on the average includes only four other varieties: blackfin snapper, amberjack, yellowfin grouper, and red hind.

Mona Passage area

In the Mona Passage area, there exist relatively extended island shelves, one on the east coast of Hispaniola and another on the west coast of Puerto Rico, with a few offshore banks in between. The species caught were similar to those north of Hispaniola, but the catch rates were very low ranging from nil to 6.1 pounds/line/hour. Strong northerly currents between Mona Island and the east coast of Hispaniola are totally unfavorable to bottom fishing for deepwater species. The shelf west of Puerto Rico has been intensively fished by pot fishermen of the area. Catch details are given in Table A-6.

Table A-6.—Catch rate at specific locations—Mona Passage.

Fishing ground	Month	Depth range fished (fm)	Hours fished	Catch rate (lb/line/hr)
East end shelf of Hispaniola	Mar. 1969	40-100	4	0.4
	Sept. 1967	50-60	6.3	1.7
Isla Monito	Sept. 1967	28-60	7.5	5.8
Isla Monito & Mona Island	Mar. 1969	42-90	2.1	0.3
Placer Bank	Mar. 1969	44-91	1.5	Nil
Sponge Bank	Sept. 1967	16-30	0.8	Nil
	Mar. 1969	16-110	16.3	0.0

Table A-7.—Catch rates at specific locations—Puerto Rico and Virgin Islands shelf.

Fishing ground	Month	Depth Range fished (fm)	Hours fished	Catch rate (lb/line/hr)
Puerto Rico S. of Ponce	Mar. 1969	20-70	15.0	4.3
Grapler Bank SE of Puerto Rico	Mar. 1969	44-50	14.3	9.8
Puerto Rico off Pta. Guyanes	Mar. 1969	80-130	2.7	8.2
Puerto Rico N of Cabo San Juan	Mar. 1969	30-90	3.4	3.3
WNW of Whale Bank	Apr. 1968	50-120	20.9	16.6
North of St. Thomas	Apr. 1968	50-120	9.1	7.5
NE of Anegada Island	Apr. 1968	50-120	11.2	5.4
Barracuda Bnk, NE edges	Apr. 1968	35-60	9.3	33.2

Puerto Rico-Virgin Islands shelf

This is a large area of about 3,450 square miles with a total length of 482 miles of shelf edge. The shelves around Puerto Rico and within reach of the local boats in the Virgin Islands have already been heavily exploited. Only a few offshore banks exist in the south off the shelves. A total of nine fishing days was spent to cover the area during April 1968 and March 1969.

Relatively productive places were on the northeast edge of Barracuda Bank, chiefly for black snapper (67 percent), and the shelf edge WNW of Whale Bank, chiefly for silk snapper (41 percent), misty grouper (31 percent), and blackfin snapper (11 percent). Other varieties of fish included in the catch from this area were yellowtail, vermillion, schoolmaster, dog snapper, and volaz (deep sea wenchman) for snappers, black, horseeye, green, bar, almaco jacks and amberjack, misty, Nassau, yellowfin, yellowmouth groupers, coney, and hinds. Table A-7 gives the catch rate by ground and month.

Leeward Islands (Fig. A-3)

In this area two large island shelves, namely Anguilla Bank and Barbuda-Antigua Bank, and a large offshore bank, Saba Bank, exist. Around these three banks a few small unnamed offshore banks are scattered. The shelves of other islands are all narrow and have been intensively fished, mostly by fish pots.

Anguilla Bank

The Anguilla Bank has an area of about 1,310 square miles with a total of 192 miles circumference. There are two small unnamed banks (31.6 square miles with 34 miles circumference) and Sombrero Bank (16 square miles with 15 miles circumference) on the northwest of the bank and a relatively large one (approximately 59 square miles with 31 miles circumference) on the southeast. A total of nearly 28 fishing days in three different months were expended on exploratory fishing in this area. The catch rates are depicted in Table A-8.

The results in Table A-8 represent only spring and fall seasons in the area and contain insufficient elements for proper comparison. The varieties of snappers were mostly black, blackfin, and silk snappers throughout the area and season. However, a few vermillion and volaz were from Sombrero and the unnamed bank, and some vermillion, yellowtail, volaz, queen, and a few mutton and dog snapper were from Anguilla Bank. These snappers comprised 72 to 99 percent of the total catch from

Sombrero and the unnamed bank and 42 to 82 percent of the total from Anguilla Bank. Jacks caught were limited to black, almaco, and horse-eye jack. These were included in the total catch at 1.0 to 6.3 percent in weight on Sombrero and the unnamed bank and 2.8 to 16.6 percent on Anguilla Bank. Groupers captured were misty, red, yellowfin, and Nassau with some hinds on the Anguilla Bank. No yellowfin or red grouper was caught from Sombrero and the unnamed bank. These species occupied 9.3 to 55.4 percent of the total catches on Anguilla Bank and nil to 25 percent on Sombrero and the unnamed bank. The range of daily catch rate in pounds/line/hour on the different edges of the Anguilla Bank were 4.8 to 21.5 on the northwest edges, nil to 32.3 on the north to northeast edges, 5.6 to 19.0 on the north edges of the eastern part, and 4.8 to 30.7 on the east tip. The slope edges of the Anguilla Bank were generally very steep, falling to more than 100 fathoms from 30 to 50 fathom edges. The fishing was most effective where comparatively gradual slopes exist, such as the east tip or the north tip of the bank. A total of 10 nights' fishing, mostly 32 to 38 fathoms at anchorage near the east tip of the bank, produced almost the same main varieties of fish as those in daytime, but most of the yellowtail snapper and horse-eye jack were caught during night fishing. The catch rate ranged from 4.8 to 21.4 pounds/line/hour with a total average of 13.4 pounds.

Body temperatures of some species from various depths were measured during April 1968 on Anguilla, Sombrero, and Barracuda Banks. The results are given in Table A-9.

It is not certain that the body temperature coincides with that in their living water layer because of no simultaneous bathythermograph cast. However, the body temperature of snappers apparently changes with depth and has a small deviation among individuals at equal depths. Though the measurements are insufficient to draw definite conclusions, it is thought that those of black jack and yellowfin grouper indicate some relatively large vertical movements of short duration.

Saba Bank, which lies several miles west of Saba Island, has been exploited only by a few motor fishing boats (25 to 45 foot) from nearby islands. The catch from those boats ranges from 500 to 1,800 pounds for a 4- to 6-day trip with a crew of three to five. One of the two mother ship operation units described in this paper carried out some exploratory fishing in August 1967 utilizing bottom longline methods by the catcher boats and handline methods by the mother ship itself. The daily catch ranged from only 130 to 500 pounds. The area of the bank is about 644 square miles and the circumference is nearly 107 miles. One small unnamed bank (10 square miles with 24 miles circumference) exists a few miles to the north.

Throughout the exploratory period by handline and reel methods, only 1 day was spent on this area covering some edges on the east and north of the bank and the small bank. The result was almost negative, producing only 18 fish (62 pounds) of various species from 70 to 130 fathom shelf edges from 6.3 hours fishing. Some extensive seasonal coverage in this area utilizing pot methods (which followed the exploratory period), however, disclosed rather productive bottoms along the northern edges, chiefly for silk snapper.

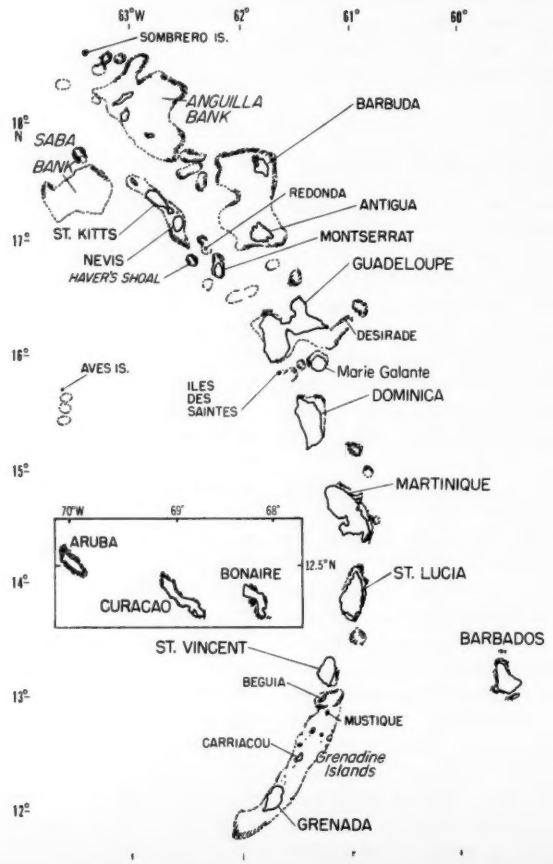

Figure A-3.—Area of operations—Leeward and Windward Islands waters, Aves Island, Aruba, Curacao, and Bonaire.

Barbuda-Antigua Bank

Barbuda-Antigua Bank has an area of nearly 978 square miles with about 163 miles circumference. On the bank, two relatively large islands exist, Barbuda Island in the north and Antigua Island in the south, 25 miles apart. From these two islands more than 60 boats, of which about 50 are equipped with inboard engines, are fishing on this bank, most of them concentrated on the Antigua shelf. The annual landing from this bank is around 1.6

Table A-8.—Catch rates at specific locations—Sombrero Island-Anguilla Bank.

Fishing ground	Month	Depth range fished (fm)	Hours fished	Catch rate (lb/line/hr)	Dominant species
Sombrero Island	Apr. 1968	50-120	11.8	21.0	BK-SK[1]
	May 1969	50-125	20.0	6.2	BK-SK
	Oct. 1968	93-120	4.3	6.1	SK-BF
Unnamed bank NW of Anguilla Bank	Apr. 1968	50-120	8.5	18.4	BK-SK
Anguilla Bank NW edges	Apr. 1969	28-111	7.3	6.0	BK-SK
	Oct. 1968	30-100	1.2	17.3	BF-SK
Anguilla Bank N to NE edges	Apr. 1968	50-120	12.2	32.3	BF-BK
	May 1969	50-150	18.0	9.4	BK-BF
	Oct. 1968	27-126	5.7	10.6	SK-BF
Anguilla Bank NE in the east	Apr. 1969	36-38	10.2	12.7	BF-SK
	May 1969	75-150	8.0	7.2	BF-SK
	Oct. 1968	45	1.7	5.6	BF-O
Anguilla Bank East tip	Apr. 1968	50-60	10.5	17.6	BF-BK
	Apr. 1969	34-129	128.9	14.8	BF-BK
	May 1969	50-125	18.0	8.3	SK-BF
	Oct. 1968	35-135	26.2	23.8	BF-BK
Anguilla Bank SE edge	May 1969	50-125	10.0	5.9	BF-SK

[1]BK = black snapper, BF = blackfin snapper, and SK = silk snapper.

million pounds. A few small offshore banks (a total of 2 square miles circumference) lie on the west side of Barbuda Bank.

The project vessels, from a total of 13 days fishing in this area, produced relatively high catch rates along the northern half of the Barbuda Bank including the offshore banks, in spite of the short distance from the coastline of Barbuda. The catches were composed of 65 to 92 percent snapper, 3 to 33 percent jacks, and 0 to 14 percent groupers. The variety of snapper was chiefly silk, but blackfin and black snappers were also common and a few vermillion, queen, and dog snappers were taken. Except for one night when three horse-eye jacks were caught, amberjack or almaco and black jacks were the only species of the jack group captured. Yellowfin, misty, red, and Nassau groupers and hinds were the common varieties of the grouper. The daily catch rate ranged from 8.6 to 19.8 pounds/line/hour on the northeast to north edges and 7.0 to 30.2 pounds on the west edges of Burbuda Bank. Table A-10 shows the catch rate by month and area.

St. Kitts to Dominica

The other island shelves in the Leeward Islands are generally narrow and exploited intensively with fish pots by the local fishermen. Table A-11 gives the approximate area and the circumference of the shelves of these islands, including neighboring offshore banks. The fishing month and depth range in the last two columns in the table are supplementary to the information in Table 2.

As shown in Table 2, the catch rates (the catch rate in Table 2 is for 10-hour fishing periods) obtained from the edges of these southern Leeward Islands shelves were very poor, being less than 2.3 pounds/line/hour, except Haver's shoal and Redonda Island shelf which showed comparatively higher catch rates of 8.9 to 15.0 pounds/line/hour. The variety of fish caught from these areas were similar to those from the northern Leeward Islands except that queen snapper were included in the common species of snapper.

Windward Islands

The island shelves and their utilization in the Windward Islands are very similar to those in the southern Leeward Islands—narrow and extensively fished, except for the Grenadine Islands shelf which has an area of about 1,010 square miles. Offshore banks are few and small, most of them lying within reach of the local fishing boats. Table A-12 gives the area and perimeter of each shelf, with the fishing month and depth range in the last two columns.

Despite an ample geographic coverage transecting the edges of these shelves with echo sounder and test fishing, the catch results were mostly very poor. Eighteen out of a total of 28 fishing days in these areas produced practically zero catch. The most productive area was around the south tip of the Grenadine Island shelf where 9.2 to 11.0 pounds/line/hour was obtained. The catch was composed of 65 percent snapper (chiefly blackfin), 32 percent jacks (black, green, amberjack, and horse-eye), and 3 percent

Table A-9.—Body temperature of some fish species caught in Leeward Islands (°C).

Depth (fm)	Black snapper	Blackfin s.	Silk snapper	Blackjack	Yellowfin grouper	Time (hr)	Surface w. temp. (°C)	Area
	(7)* + 0.3**:	(2) + 0.0	—	—	—			
39	25.2 − 0.2	25.2 − 0.0				14	26.3	Barbados
	(5) + 0.3	(1)		(7) + 0.2				
53	24.9 − 0.4	25.2	—	25.3 − 0.3	—	15	25.7	Anguilla (E)
	(5) + 0.7	(5) + 0.2	(1)	(1)				
54	24.3 − 1.3	24.3 − 0.3	24.0	24.0	—	14	26.3	Barbados
	(3) + 0.3	(4) + 0.1						
70	24.2 − 0.2	24.0 − 0.3	—	—	—	08	25.4	Anguilla (NE)
	(5) + 0.5							
80	22.6 − 06	—	—	—	—	11	25.5	Sombrero
	(1)	(1)	(1)		(1)			
90	22.8	22.8	22.0	—	18.0	08	25.4	Anguilla (NE)
		(1)	(1) + 0.5					
100	—	22.0	20.5 − 0.8	—	—	11	25.5	Sombrero
	(1)	(1)						
100	22.0	22.7	—	—	—	08	25.4	Anguilla (NE)
	(2) + 0.1	(1)		(3) + 0.1				
110	23.2 − 0.1	23.5	—	25.4 − 0.2	—	10	25.6	Anguilla (E)

*Figure in parenthesis shows number of fish measured.
**Deviation from maximum and minimum

Table A-10.—Catch rates at specific locations—Barbuda-Antigua Banks.

Fishing ground	Month	Depth range fished (fm)	Hours fished	Catch rate (lb/line/hr)
Barbuda, N-NE edges	May 1969	50-130	40.5	11.9
	Nov. 1968	36-125	4.1	16.0
W. edges	May 1969	55-100	17.5	10.8
Small banks W of Barbuda Bank	Apr. 1969	36-110	9.7	6.1
	Nov. 1968	24-135	40.5	17.8
Between Barbuda & Antigua E edge	Nov. 1968	42-120	1.1	3.5
Antigua S-SE edges	Apr. 1968	60-110	5.9	0.0

Table A-11.—Principal characteristics of specific localities fished—St. Kitts-Dominica.

Name of shelf	Area (sq. mil.)	Perimeter (miles)	Fishing month	Depth range fished (fm)
St. Kitts-Nevis	219	109	Nov. 1968	30-135
Redonda	38	24	Apr. 1968	60-120
Montserrat	41	33	Nov. 1968	42-135
Havers Shoal	1.9	4.8	Nov. 1968	28-130
Three banks in Guadeloupe passage	45	55	Dec. 1968	
Guadeloupe	444	159	Dec. 1968	30-140
Flandre Bank	10.3	10	Dec. 1968	30-138
Marie Galamte Is.	39	36	Dec. 1968	30-120
Ile des Saintes etc.	67	33	Dec. 1968	—
A bank between Marie-Galante & Ile des Saintes	11	14	Dec. 1968	—
Dominica	97	78	Nov. & Dec. 1968	12-111
A bank SE of Dominica	40	25	Nov. & Dec. 1968	45-135

mixed fish with grouper, grunt, and squirrelfish. A short period of fishing on the north edge of Dominica Island shelf caught fish (85 percent black jack) at a rate of 5.2 pounds/line/hour. Around the south tip of the St. Lucia Island shelf, daily catch rates of 1.6 to 4.4 pounds/line/hour (77 percent queen snapper) were obtained from the 75 to 150 fathom slopes. These catch rates are probably good only for the local fishing boats equipped with outboard engines, whose cost of operation and depreciation rate are very low. The remainder of the shelves in this area give less than 1.0 pound/line/hour.

Aves Island Area

The Aves Island (or Bird Island) and several small offshore banks exist about 120 miles west of Dominica. The total area of these shelves is approximately 17 square miles and their edges total 35 miles long. The exploratory fishing was extended to this area during May and August 1969. A total of 8 hours transecting bottoms of these banks during May found no proper spot for snapper fishing. One hour's fishing in August captured only two coneys (1 pound) from 13 fathoms bottom. It is interesting that one black jack in August 1967 and six black jacks in August 1969 were captured with other pelagic species while surface trolling in this area.

Table A-12.—Principal characteristics of specific localities fished—Windward Islands.

Name of shelf	Area (sq. mil.)	Perimeter (miles)	Fishing month	Depth range fished (fm)
Martinique Is.	353	106	Dec. 1968	24-207
A bank ENE of Martinique	18	17	Nov. & Dec. 1968	45-135
St. Lucia Is.	157	84	Jan. 1969	30-153
A bank south of St. Lucia	2.5	5	—	—
St. Vincent Is.	43	49	Jan. 1969	To-125
Grenadine Is.	1,010	234	Jan. & Feb. 1969	22-135
Barbados Is.	89	60	Mar. 1969	18-280
The shallows	18	18	Mar. 1969	25-75

Table A-13.—Catch rates—Aruba-Curacao-Bonaire area.

Fishing ground	Month	Depth range fished (fm)	Hours fished	Catch rate (lb/line/hr)
Aruba Island	May to June 1969	10-104	19	2.2
Bonaire Is.	May to June 1969	—	37	0.8
Curacao Is.	May to June 1969	—	45	1.0

Aruba-Curacao-Bonaire Area

The shelves of these three islands are very narrow having widths of less than 1 mile. Only the north and south shelves of Aruba Island are slightly broader, 5 miles and 2 miles, respectively, the east side of the shelf being connected by a 104-fathom sea floor to the north edge of the Venezuela shelf. A total of 23 fishing-days were spent on exploratory fishing for snappers and related species on these shelves during the months of May and June 1969, Table A-13. The catch results on these shelf slopes were mostly very poor, the catch rates ranging from 0 to 0.8 pounds/line/hour on the Bonaire shelf, 0 to 1.0 pound on the Curacao shelf, and 0.3 to 8.1 pounds on the Aruba shelf, the north edge of the Aruba shelf being comparatively productive. The catch was composed of snappers (38 to 45 percent in number), jacks (6 to 24 percent), groupers (6 to 27 percent), and trash fish (24 to 31 percent).

The majority of the snapper species was mainly blackfin with some queen, silk, vermillion, and volaz. The jack species were mostly amberjack, but some black and horse-eye jacks were present.

Continental Shelf of South America from Trinidad to French Guiana

The continental shelf of South America is 50 to 90 miles wide from the coastline to the shelf edge of the 100-fathom line. The area and the edge line are about 57,400 square miles and 930 miles long from the north of the west boundary of Trinidad to northeast of the Oyapock River, the east boundary of French Guiana (Fig.A-4).Aspreviouslystated,commercial snapper fishing on this shelf has existed for past decades, but the number of vessels operating there has not increased. It is estimated, however, that a considerable amount of snapper has been and is being caught incidentally by those shrimp trawlers (402 vessels in 1969) operating on the interior part of the shelf (10 to 35 fathoms) where lane snappers, vermil-

lion snappers, and some Caribbean red snappers are present.

The exploratory fishing by the project vessels covered almost all of the likely bottoms for snappers along the edge of the shelf as well as the interior part of the shelf. Most of the bottom of this vast shelf has a featureless smooth bottom with a gradient of 1 fathom or 2 for every 2 miles or a slow slope on the edges, with, of course, some exceptions. Generally, fish schools were not found by echo sounder on these bottoms, but they were located on some outcrops or so-called "hard bottom" on the shelf, around ridges or rugged bottoms near the edges, or on the reasonably steep edge slopes where the deep ocean floor is close to the edge. Further details of catch results and good fishing grounds by area are as follows.

Shelves around Tobago and east of Trinidad.—The catch results around Tobago and the eastern shelf of Trinidad were generally poor (Table A-13). The catch rate by area around Tobago ranged from 0 to 13.2 pounds/line/hour, the edges east of the island being more productive while the shelf south to southwest of the island yielded mostly zero catch. The dominant species on the slope edges were Caribbean red snappers and black jack. A few yellowedge grouper, amberjack, and coneys were included in the catch. The catch rate along the shelf edges east of Trinidad ranged from 0 to 32.2 pounds/line/hour. The best catch was obtained on the 60 to 70 fathom bottom around 10°27′N. The inward shelf yielded few fish. The dominant species for snapper were Caribbean red snapper, vermillion snapper, and yellowedge grouper. Some blackfin snapper, Warsaw grouper, and porgy were included in the catch. Table A-13 gives further details by month and area.

Shelves east of Orinoco River (lat.10°N to 9°N)—From a total of seven days spent in this area, two narrow areas—edges around lat. 9°40′N and around lat. 9°05′N—showed good catch rates, 17.4 and 25.7 pounds/line/hour, respectively. Catches from the inward shelf were almost nil. On these edges Caribbean red snapper, blackfin snapper, and vermillion snapper were the main snapper species, but in total weight,

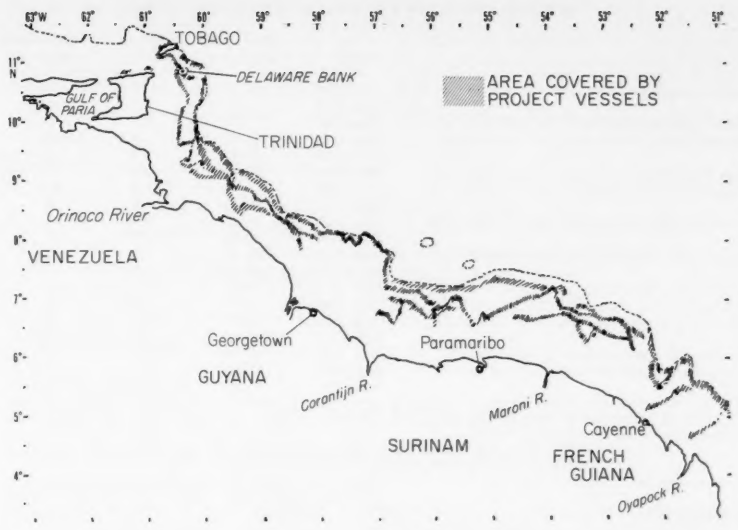

Figure A-4.—Area of operations—continental shelf of South America from Trinidad to French Guiana.

Table A-13.—Catch rates at specific locations of Trinidad and Tobago.

Fishing ground	Month	Depth range fished (fm)	Hours fished	Catch rate (lb/line/hr)
Around Tobago	Feb.-Mar. 1969	22-150	59.1	2.6
	Dec. 1970	29-90	0.7	0.0
Inward shelf east of Trinidad	Dec. 1970	9.46	1.9	2.7
East of Delware Bk.	Mar. 1969	37-120	17.6	0.1
Edges from 10°N to 10°30′N	Dec. 1970	46-70	4.6	15.3

Table A-14.—Catch rates at specific locations—shelves east of Orinoco River.

Fishing ground	Month	Depth range fished (fm)	Hours fished	Catch rate (lb/line/hr)
Inward shelf N of Orinoco River	Dec. 1970	30-44	0.1	0.0
Edges from 10°N to 9°30′N	Dec. 1969	36-90	9.5	0.4
	Dec. 1970	33-100	4.0	16.8
Edges from 9°30′N to 9°18′N	Dec. 1969	45-49	11.3	0.0
	Dec. 1970	34-61	0.2	1.6
Edges from 9°18′N to 9°N	Dec. 1970	55-100	2.3	23.7
Inward shelf N of Waini R.	Dec. 1970	33-42	0.1	0.0

groupers, chiefly yellowedge grouper, sometimes contributed more than snapper to the total catch. The catch rate by specific locality appears in Table A-14.

Shelves off Guyana.—A total of 19 fishing days was spent in this area. Considerable echo sounding transects were run on the slope edges as well as likely bottoms (30 to 40 fathoms) on the inward shelf. The shelf edges usually have a steep gradient, but the shelf proper was largely even excepting for some very small bottom outcrops. As shown in Table A-15, the three best catches were produced from such outcrops (about 6 feet high) on the inward shelf in this area. One in November 1969 produced 7,400 pounds of fish in 2 days by *Fregata*, and one in December 1970 by *Calamar*, caught nearly 7,700 pounds of fish in less than 8 hours fishing in 2 days. These catch rates averaged 95 to 137 pounds/line/hour with more than 99 percent of the total being Caribbean red snappers. The snapper caught by the *Fregata* averaged 6.6 pounds each while those caught by the *Calamar* averaged 8.1 pounds each. The former area is located at about lat. 8°18′N, long. 58°32′W (34 fathom bottom) and the latter at lat. 8°46′N, long. 59°12′W, about 50 miles northwest from the former. Fishing during the December 1970 *Calamar* cruise at the former position and March 1971 cruise at the latter position, showed no sign of the fish school. It is likely that those large schools of fish move from one small outcrop to another due to a limited supply of food. The shelf edge with rather steep gradient displayed good potential. Relatively

Table A-15.—Catch rates at specific locations—shelves off Guyana.

Fishing Ground	Month	Depth range fished (fm)	Hours fished	Catch rate (lb/line/hr)
Inward shelf between long. 59° & 59½°W	Dec. 1969	35-45	11	0.5
	Dec. 1970	33-51	16.0	133.4
Shelf edge between long. 59° and 59½°W	Dec. 1970	45-52	0.3	0
Inward shelf between long 59° and 58½°W	Dec. 1969	35-45	10.9	0.1
	Dec. 1970	34-47	0.9	3.7 (3.4)*
Shelf edge between long. 59° and 58½°W	Dec. 1970	45-100	8.5	12.5 (9.9)*
Inward shelf between long. 59° and 58½°W	Nov. 1969	34	17.6	84.5
	Dec. 1970	30-52	(6.3)**	0
Inward shelf between long. 58½° and 58°W	Dec. 1969	31-34	2.5	0
	Dec. 1970	30-60	0.3	0
Shelf edge between long. 58½° and 58°W	Sep. 1969	27-95	5.0	0.2
	Dec. 1970	45-120	3.8	7.2
Shelf edge between long. 58° and 57½°W	Nov. 1970	47-68	2.8	12.1
Inward shelf between long. 58° and 57½°W	Aug. 1969	22-59	8.9	10.2
Shelf edges between long. 57½° and 57°W	Aug. 1969	45-60	23.5	8.9
	Nov. 1970	50-57	5.4	12.3
Shelf edge between long. 57° and 56½°W	Nov. 1970	49-150	3.0	5.9
Inward shelf between long. 57° and 56½°W	Aug. 1969	22-40	33.8	5.9
	Nov. 1970	35-36	(1.5)**	0.0

*Catch rate from night fishing.
**Hours spent for scouting and fishing.

Table A-16.—Catch rates at specific locations—shelves off Surinam.

Fishing ground	Month	Depth range fished (fm)		Hours fished	Catch rate (lb/line/hr)
Shelf edge between					
long. 56½° and 56°W	Aug. 1969	45-65		10.4	8.8
	Nov. 1970	51-75	0.8	(7.8)*	9.1
Long. 56° and 55½°W	Nov. 1970	56-145	0.7	(9.0)	2.4
Long. 55½° and 55°W	Nov. 1970	50-250	3.9	(15.4)	11.2
Long. 55° and 54½°W	Nov. 1970	55-120	0.5	(8.0)	0.0
Long. 54½° and 54°W	Nov. 1970	48-55	0.6	(5.5)	0.0
Long. 54° and 53½°W	Nov. 1970	45-52	0.6	(5.3)	0.0
Inward shelf between					
Long. 56½° and 56°W	Aug. 1969	35-38		33.2	24.7
	Nov. 1970	30-37	0.8	(6.3)	8.1
Long. 56° and 55½°W	Aug. 1969	34-54		18.8	6.6
	Nov. 1970	33-34	0.6	(4.6)	0.0
Long. 55½° and 55°W	Aug. 1969	27-60		9.5	3.5
	Nov. 1970	33-34	0.2	(4.8)	0.0
Long. 55° and 54½°W	Aug. 1969	27-35		11.0	0.6
	Nov. 1970	32-33	0.7	(3.8)	0.0
Long. 54½° and 54°W	Nov. 1970	30-50	0.2	(6.6)	0.0
Long. 54° and 53½°W	Oct. 1969	32-53		33.4	7.8

*Figures in parenthesis show total scouting and fishing hours.

Table A-17—Catch rates at specific locations—shelves off French Guiana.

Fishing Ground	Month	Depth range fished (fm)		Hours fished	Catch rate (lb/line/hr)	
Shelf edge between long. 53½° and 53°W	Oct. 1969	27-53		31.0	17.4	
	Oct. 1970	50-95	8.4	(14.8)*	2.6	
Long. 53° and 52½°W	Oct. 1969	43		24.5	7.0	
	Oct. 1970	50-85	2.4	(9.5)	11.4	
Long. 52½° and 52°W	Oct. 1969	43-55		20.0	4.4	
Offshore bank and edges between long. 52½° and 52°W	Oct. 1970	41-65	5.5	(18.8)	9.6	
Shelf edge between long. 52° and 51½°W	Oct. 1970	43-65	47.6	(133.0)*	17.6	(33.5)**
Long 51½° and 51°W	Oct. 1970	52-61	1.2	(11.4)*	19.9	
Inward shelf between 53½° and 53°W	Oct. 1969	27	6.3			* 0.0
	Oct. 1970	30-50	0.2	(14.7)*	0.0	
Long. 53° and 52½°W	Oct. 1970	30-41	0.0	(2.8)*	0.0	
Long. 52½° and 52°W	Oct. 1970	35-38	1.1	(6.0)*	6.6	
Long. 52° and 51½°W	Oct. 1970	25-35	1.8	(11.7)*	6.3	
Long. 51½° and 51°W	Oct. 1970	30-50	1.8	(11.3)*	4.5	

*Total scouting and fishing hours.
**Catch rate from night fishing.

productive positions were on the shelf edges around the longitudes of 58°45′W, 57°41′W, and 57°19′W. The varieties of the catch were chiefly Caribbean red snapper with some vermillion snapper and a trace of blackfin snapper. A few large amberjacks (13-20 pounds each) and one or two yellowedge, Warsaw, and/or yellowmouth groupers were also caught. Further details of catch results by localities are given in Table A-15.

Shelves off Surinam.—During the months of August and October 1969, exploratory fishing off Surinam was centered mainly on the inward shelf from 27 to 60 fathoms. The catch rate averaged 9.4 pounds/line/hour with a range from 0.6 to 34.9. The higher catch rates were obtained in 33 to 40 fathoms between long.56.5°W and 56°W, and in 37 fathoms around lat.7°08′N, long.53°44′W. During the month of November 1970, a total of 29.3 hours in about two fishing days was spent to cover a belt of 30 to 37 fathoms bottom (a total distance of 170 miles) along the coast. Only 18 small schools were located at an average interval of about 9.5 miles. From the 18 drifts on the schools, in 2 hours 9 minutes actual fishing time, the average catch rate was estimated at about 4.3 pounds/line/hour, yielding mostly zero catches excepting for the first area (long. 56.5°W to 56°W), which produced 15.4 pounds/line/hour.

On the shelf edges, during the later cruise, a total of 90.4 hours in eight fishing days covered about 270 miles. More fish schools were found along these edges than on the inward shelf. A total of 77 drifts was made into the fish schools with 13.1 hours of actual fishing. The average interval of these fish schools is about 3.5 miles. Estimation of catch rate from a total of 78.6 reel hours fishing effort and the catch (854 pounds) is 10.9 pounds/line/hour. The catch rates ranged from 0 to 13.1 pounds/line/hour with higher catch rates from the edges between the longitudes of 55°W and 55.5°W.

The catch in this area comprised about 33 to 85 percent snappers, 11 to 66 percent grouper, and the remainder, 1 to 4 percent, jacks and tilefish. The varieties of the catch were similar to those from the shelves off Guyana. Table A-16 gives further details of catch results by area.

Shelves off French Guiana.—The northwestern half of the shelf edge in this area has mostly a featureless gradual slope excepting for some bottom contours built up by low outcroppings on or about the 50 fathom line where some snapper schools were found. The shelf edges from about long. 52°W southeasterly were distinguished by steep slopes slanting directly onto the deep ocean floor. Inside of, but near the edges, they have favorable ridges. Numerous snapper schools were found along this 40 mile long edge. Probably the narrowness or steepness of the edge provided for more congregation of fish because

of the narrowness of the optimum depth range, as well as an advantageous biological environment. The interior part of the shelf between the edges and 30 to 33 fathoms bottom was mostly devoid of snappers and it has flat and smooth bottom features. There were some outcrops on 30 to 33 fathoms bottom, but the size of the fish schools found there was relatively small.

In October 1969 the northwestern half of this area was fished for a total of 8 fishing days, mostly near the edges at 43 to 60 fathoms. The catch rate averaged 9.8 pounds/line/hour with a range from 0 to 39.4. The catches from the inward shelves were mostly nil. A most productive ground was on 43 fathoms bottom around lat. 6°51'N, long. 53°13'W. In the same month of 1970 a total edge distance of about 200 miles and the 30 to 45 fathoms bottom on the inward shelf, about 240 miles long total, were covered in 14 fishing days. On the northwestern half of the shelf, the catch rate was 6.3 pounds/line/hour for the deeper bottoms near the edges (from 10.8 actual fishing hours out of 27.1 total hours on the grounds) and zero for the shallower bottoms on the inward shelf (from 1.3 actual fishing hours out of 23.5 total hours on the grounds). In the southeastern half the catch rates were nearly three times better at 18.5 pounds/line/hour on or near the edges (53.8 fishing hours out of 144.4 total hours) and 5.3 pounds/line/hour on the inward shelf.

The catch comprised 66 to 92 percent snappers, 7 to 26 percent groupers, and 1 to 8 percent jacks. A few tilefish and triggerfish were also present. Only three varieties of snapper were caught in this area. Caribbean red snapper was most dominant throughout followed by vermillion snapper. Lane snapper was captured only from shallower bottoms of 29 to 35 fathoms. Yellowedge, Warsaw, snowy, and yellowmouth groupers were common on the shelf edges, but on the shallower bottoms on the inward shelf only snowy, yellowedge, and red groupers were common. Jacks were rare in daytime fishing, only a few amberjacks and green jacks being caught. From one night's fishing 27 horse-eye jacks (427 pounds) were captured from 2 hours fishing on rugged 55 fathom bottom near the shelf edge, but from only one location (lat. 5°53'N, long.51°34'W). Table A-17 gives further details of the catch rate by fishing ground.

The currents were generally strong to the northwest throughout this area. On many occasions it was impossible to hold the vessel onto a fish school or to reach the bottom with the 6 to 9 pound sinkers on the fishing lines when the vessel was anchored to maintain position.

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MFR PAPER 1084

Results of Live Bait and Pole and Line Fishing Explorations for Pelagic Fishes in the Caribbean

DONALD P. WAGNER

ABSTRACT—This paper presents results of exploratory fishing in the Caribbean for live bait and for tuna, using the pole and line method, 1967-1970. Seasonal fluctuations in abundance of both bait and tuna stocks were evident. Bait fishes were caught throughout the Caribbean but were most abundant off the Windward Islands, Trinidad, and Tobago. Catches of bait ranged up to 700 pounds per station and were primarily Atlantic thread herring, Opisthonema oglinum; *dwarf herring,* Jenkinsia lamprotaenia; *pilchards,* Harengula *sp.; and sardines,* Sardinella *sp. Tuna catches were as high as 73 pounds per hour and were mostly skipjack,* Katsuwonus pelamis. *During 1970, an intensive survey near the Windward Islands produced catches averaging 24 pounds per hour.*

INTRODUCTION

From March 1967 through June 1970, the United Nations Development Program/Food and Agriculture Organization Caribbean Fishery Development Project (CFDP) made live-bait surveys and pole and line fishing explorations as part of investigations of available fishery resources in the Caribbean Sea and surrounding waters. The following objectives were set:

1. Develop information on the availability of live bait suitable for pole and line fishing.
2. Define the geographical and seasonal distribution of surface schooling fishes, principally tunas.
3. Conduct experimental tuna fishing by the pole and line method.

Exploratory fishing operations in 1967, 1968, and 1969 extended from the coast of British Honduras to Jamaica, Hispaniola, and Puerto Rico, thence south along the Antillean Arc to Trinidad and west along the north coast of South America to about long.75°W. The area surrounding the Windward Islands received the most extensive coverage in these 3 years due to encouraging reports from the U.S. Bureau of Commercial Fisheries research vessels *Geronimo* and *Undaunted*[1] and earlier results obtained by the CFDP that indicated a relatively greater abundance of tuna schools in this area. From January through June 1970, more concentrated surveys were made in the area west of the Windward Islands bounded by the St. Lucia Channel to the north and the southern tip of Grenada to the south.

The vessels used were the *Calamar, Alcyon,* and *Fregata.* They were designed as combination, multipurpose

[1] RV *Undaunted* Cruise Reports 66-2, 66-5, 67-1, and RV *Geronimo* Cruise Report 66-7 are available from the Southeast Fisheries Center, National Marine Fisheries Service, NOAA, 75 Virginia Beach Drive, Miami, FL 33149.

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exploratory fishing/training vessels but differed significantly in size, configuration, and adaptability to different types of fishing. None of the vessels were ideally suited to live-bait/pole and line fishing.

LIVE-BAIT SURVEYS

Between March 1967 and June 1970, 263 baiting stations were made at 92 locations. Approximately 6,118 buckets of bait[2] were caught by lift net, lampara, and beach seine (see Appendix Table 1). Fifty percent of the stations were in the Windward Islands because they were closest to the best potential pole and line fishing areas. The yield of bait per station was highest in Trinidad, particularly Chaguaramas Bay (95.9 buckets) and Chupara Bay (61.9 buckets). High yields were also obtained in and around St. George's, Grenada, and Lime Cay, Jamaica.

In January 1970, a bait survey was made in the Windward Islands to further investigate bait resources between St. Lucia Channel and Grenada. This investigation was designed to find locations other than Grenada and Trinidad as possible points to replenish bait supplies during the scheduled concentrated pole and line fishing efforts of 1970. Of several locations explored during this period, Cumberland Bay, St. Vincent was the only new location that appeared to hold promise of a fairly continuous bait supply.

Three methods of live bait capture were used: beach seine, lampara or bag net, and the lift or blanket net (Radovich and Gibbs 1954). The lift net was the most effective method of catching bait fishes and was used on more than 90 percent of the live-bait stations occupied throughout the 4 years of investigations and exclusively in 1970.

The lift net was 16.5 m long and 12.8 m wide. The netting was made of

[2] One bucket of bait represents approximately 5 to 7 pounds of fish.

Table 1.—Bait species and catch by location.

	Species[1]						
	AN	DH	PL	RS	SA	SI	TH
	Number of buckets						
Northern Caribbean							
Jamaica	108.0	238.0	16.5	0	0	53.0	98.0
Dominican Republic	30.0	132.0	28.0	0	0	0	6.0
Puerto Rico	75.0	0.5	0	0	0	0	296.0
Honduras	0	0	0	0	0	0	0
Total	213.0	370.5	44.5	0	0	53.0	400.0
Northeastern Caribbean							
St. Martin	0	0	0	0	0	2.0	0
St. Barthélemy	0	0	0	0	0	0	0
Barbuda	0	0	16.0	0	0	0	0
Guadeloupe	0	0	0	0	0	1.0	0
Dominica	14.0	0	9.0	0	0	0	0
Total	14.0	0	25.0	0	0	3.0	0
Southeastern Caribbean							
Martinique	33.5	0	0	9.0	18.0	9.0	0
St. Lucia	15.0	0	15.0	0	59.0	25.5	29.5
St. Vincent	0	5.5	8.0	16.5	5.5	1.5	239.5
Grenada	49.0	799.0	916.0	35.0	0	0	0
Barbados	0	0	0	0	0	27.5	6.0
Grenadines (north sector)	0	0	2.5	112.5	0	2.5	112.5
Carriacou (south sector)	17.0	0	0	17.0	17.0	0	17.0
Petit Nevis	0	0	0	0	0	6.0	0
Union Island	0	0	11.5	0	0	0	0
Total	114.5	804.5	953.0	190.0	99.5	72.0	404.5
Southern Caribbean							
Tobago	0	0	3.0	89.0	0	0	0
Trinidad	0	0	583.0	0	774.0	0	0
Venezuela	0	0	0	0	87.0	0	0
Total	0	0	586.0	89.0	861.0	0	0

[1] AN = anchovy (Engraulidae)
DH = dwarf herring (*Jenkinsia*)
PL = pilchards (*Harengula*)
RS = round scad (*Decapterus*)
SA = sardine (*Sardinella*)
SI = silversides (Atherinidae)
TH = thread herring (*Opisthonema*)

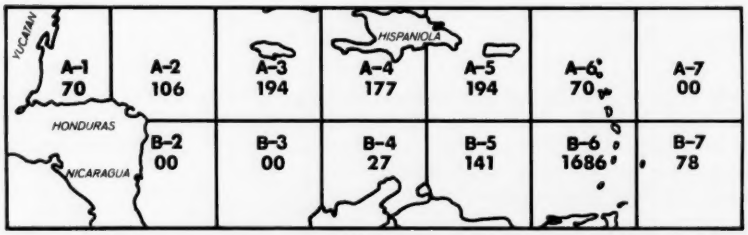

Figure 1.—Number of hours expended in exploratory fishing by 5° latitude and longitude from March 1967 through June 1970.

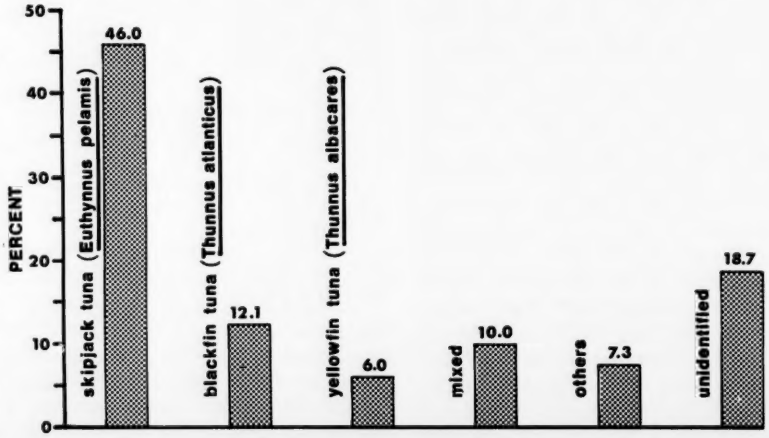

Figure 2.—Frequency of fish school sightings by species.

Table 2.—Summary of effort, pelagic fish schools sighted, and the rate of sightings expressed in sightings per hour for 1967, 1968, 1969, and 1970.

Month	Gulf of Honduras (Area A1)			Eastern Honduras (Area A2)			Jamaica (Area A3)			Western Hispaniola (Area A4)			Puerto Rico (Area A5)			Leeward Islands (Area A6)			Venezuela-Colombia coast (Area B4)			Netherland Antilles (Area B5)			Windward Islands (Area B6)			Barbados (Area B7)		
	HE[1]	SS[2]	S/H[3]	HE	SS	S/H	HE	SS	S/H	HE	SS	S/H	HE	SS	S/H	HE	SS	S/H	HE	SS	S/H	HE	SS	S/H	HE	SS	S/H	HE	SS	S/H
Jan.							12	00	0.00	48	1	0.02	67	16	0.24										178	4	0.02			
Feb.							17	1	.06	47	7	.15	18	7	.39										351	92	.26	21	1	0.05
Mar.							10	00	.00	45	9	.20	48	8	.17										362	80	.22	29	5	.17
Apr.	70	00	0.00	44	3	0.07	22	2	.09							14	2	0.14							149	78	.52	6	1	.17
May																									198	48	.24	30	00	.00
June							7	00	.00	31	00	.00	40	00	.00	20	1	.05	17	00	0.00	70	7	0.01	73	10	.14			
July							119	00	.00	5	2	.40	21	13	.62							16	00	.00	38	10	.26			
Aug.							7	00	.00	1	00	.00													10	00	.00			
Sept.																36	3	.08	10	3	.03	55	9	.16	262	32	.12	11	00	.00
Oct.																									65	4	.06			
Nov.																														
Dec.				62	11	.18																								
Total	70	00	0.00	106	14	0.13	194	3	0.02	177	19	0.11	194	44	0.23	70	6	0.09	27	3	0.11	141	16	0.11	1,686	358	0.21	78	7	0.09

[1]HE = Hours of effort. [2]SS = Schools sighted. [3]S/H = Sightings per hour.

Table 3.—Monthly results of pole and line fishing in 1970.

	Schools sighted	Schools fished	Total hours of effort	Total pounds caught	Catch rate
FEB.	4	0	180	0	0.0
MAR.	58	22	225	4,926	21.9
APR.	49	29	216	7,752	35.9
MAY	23	9	81	5,907	72.9
JUNE	10	0	63	0	0.0

synthetic fiber with 1.25 – cm stretched mesh in its center and outboard sections and 7.5 – cm mesh in the inboard section. The inboard section of the net was fastened to the boat rail and the outboard corners were suspended from two outrigger poles, 9.1 m long, that extended horizontally at right angles to the rail of the vessel. The net was operated as described by Radovich and Gibbs (1954).

The abundance of different bait species varied throughout the Caribbean. I divided the Caribbean into four regions:

1. Northern Caribbean — Jamaica, Dominican Republic, Puerto Rico, and Honduras.
2. Northeastern Caribbean — St. Martin, St. Barthélemy, Barbuda, Guadeloupe, and Dominica.
3. Southeastern Caribbean — Martinique, St. Lucia, St. Vincent, Grenada, Barbados, and the Grenadines.
4. Southern Caribbean — Trinidad, Tobago, and Venezuela.

In the northern Caribbean, thread herring and dwarf herring were the most abundant species. In the northeastern Caribbean, where relatively little live bait exploration took place, pilchards were most numerous, and in the southern Caribbean, sardines and pilchards were most abundant (Table 1).

FISHING SURVEYS

Twenty-eight exploratory pole and line fishing cruises, for 482 sea days, were conducted in the project region between March 1967 and June 1970. Figure 1 shows the distribution of fishing effort in the Caribbean. During daylight hours, each area was randomly searched and a watch maintained for bird flocks and fish schools. Upon sighting fish schools, attempts were made to conduct pole and line fishing. Records were maintained of time and date of sightings and whether fishing was attempted. Throughout the cruises, track charts were maintained, indicating the location of fish schools. Sightings were recorded as follows:

1. Tentative identification of species.
2. Approximate fish size.
3. Fish school association (birds, porpoises, whales, etc.).
4. Behavior of the school (jumping, breezing, etc.).
5. Estimated school size.

Fishing data were recorded similarly:

1. Time fishing started.
2. Number and species of fish caught.
3. Amount of bait used.
4. Time fishing stopped.

During 1967, 1968, and 1969, emphasis was placed on defining geographical and seasonal distribution of tunas and related surface schooling fishes. In 1970, priority was given to experimental and production fishing and was confined to the area that appeared to hold the most promise of producing the highest catches for the least amount of effort.

No set amount of effort was assigned to each school. As much as 2 hours were spent in chasing and baiting a particular school, while on other occasions very little bait was thrown and the school was abandoned early in the fishing attempt.

RESULTS

Seven species of surface schooling fishes were observed during the survey. The three most abundant species were: skipjack tuna, *Katsuwonus pelamis;* blackfin tuna, *Thunnus atlanticus;* and yellowfin tuna, *Thunnus albacares.* Dolphin, *Coryphaena hippurus;* rainbow runner, *Elagatis bipinnulata;* frigate mackerel, *Auxis* sp.; and little tunny, *Euthynnus alletteratus,* were also observed but in lesser quantities. Figure 2 is a breakdown of the frequency at which different species were observed; the three major species are classified separately and under "mixed," and the four remaining species are grouped under "others." Throughout the investigation, skipjack tuna have been the most frequently encountered species of tuna.

Even though most of the Caribbean was surveyed, except areas B2 and B3 (Figure 1), most of the effort was centered in the Jamaica to Puerto Rico area (A3, A4, and A5) and the Windward Islands (B6). These two areas were closest to our bases of operations, Jamaica to the west and Barbados to the east. Operating range, therefore, dictated this bias to some extent. Table 2 summarizes the effort, sightings, and sighting rate for the 4 years.

An analysis of the monthly variation in catch was performed only for 1970, due to the greater number of fish caught in that year. Table 3 shows the variation in catch rate from February through June 1970. February was unproductive, but there was a large increase in school sightings in March then gradually declining through June. The number of hours of effort expended in March and April are comparable, yet the catch rate increased from 21.9 pounds/hour in March to 35.9 pounds/hour in April. In May the catch rate doubled to 72.9 pounds/hour. Response to live bait appeared to be better as the season progressed. School sightings decreased sharply in June, and no fish were caught.

Most of the tuna schools encountered were small (estimated from ½ to 5 tons). In many instances more than one school could be seen at the same time in a given area. Seldom did these schools have the same biting characteristics. One school might not respond to chumming at all or remain far back in the wake of the vessel, while another school a mile away would respond very well to chumming and start biting almost immediately. No significant differences were observed in the size or species composition of these schools. Response to chumming did, however, seem to be better with the larger schools.

In 1970, observations were made on the feeding response of tuna schools to various species of bait. Anchovy and dwarf herring were the most desirable bait for attracting and holding tuna schools within catching range of the vessel. Pilchards, although available in fairly large quantities, were not as desirable. Pilchards tended to disperse, whereas anchovies and dwarf herring remained with the vessel for a longer period. In addition, pilchards were usually larger (8-10 cm) than anchovies or dwarf herring (4-6 cm), which would limit the amount of bait that could be carried.

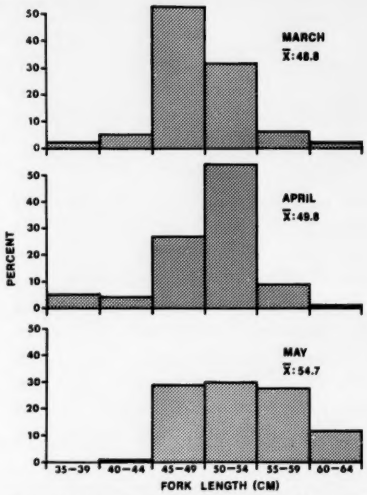

Figure 3.—Length frequencies of skipjack tuna captured during March, April, and May 1970.

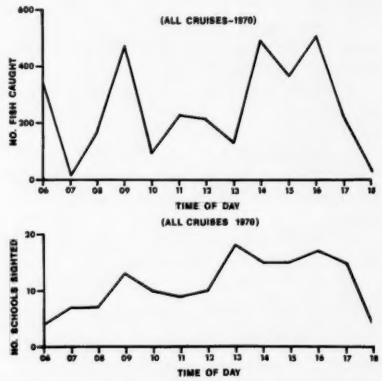

Figure 4.—Fishing success and school sightings by time of day, 1970.

Length frequencies of skipjack tuna caught during March, April, and May 1970 indicated that size gradually increased as the fishing season progressed (Figure 3). The average size increased from 48.8 cm fork length in March to 54.7 cm in May. The larger fish also seemed to respond to chumming much better than the smaller fish.

School sightings and fishing success by time of day showed similar trends (Figure 4). A morning peak around 0900 hours was followed by a low period of productivity from 1000 to 1200 hours. In the afternoon, school sightings and fishing success increased markedly until 1600 hours when a decline began.

LITERATURE CITED

Radovich, J., and E. D. Gibbs. 1954. The use of a blanket net in sampling fish populations. Calif. Fish Game 40:353-365.

Appendix I.—Bait stations.

	Station	Buckets	Dominant species[1]
Honduras	*Lift Net*		
Bonacca Island	1	0	—
Puerto Cortés	1	11.0	?
Jamaica			
Bull Bay	1	23.5	TH
Discovery Bay	1	41.0	DH
Gun Cay	1	16.5	PL
E. Kingston Harbor	1	3.0	TH
Lime Cay	13	441.5	RS, SI, TH
Long Bay	1	0	—
Morant Cays	1	0	—
Negril Bay	1	0	—
Pigeon Island	1	72.0	TH
Port Morant	2	4.0	AN
Port Antonio	3	27.5	AN, DH
Port Royal	4	68.5	AN
Port Royal Cays	1	0	—
Southwest Pedro Cays	1	0	—
Dominican Republic			
Bahía de las Calderas	1	22.0	PL
Samana Bay	6	132.5	DH
Puerto Rico			
Aguadilla Bay	1	1.0	TH
Bahía de Añasco	1	5.0	TH
Bahia de Boquerón	1	100.0	TH
Cabo Rojo	1	1.5	DA, TH
Matei Island	1	28.5	TH
Mayaqüez Harbor	6	149.0	AN, TH
Puerto Quijano	1	33.0	TH
Quaniulla	1	23.5	TH
St. Vincent			
Kingstown Harbor	3	22.0	DH, RS, SA, PL
Chateaubelair Bay	1	11.0	RS
Cumberland Bay	16	239.5	TH
Bucament Bay	1	1.5	SI
Layou Bay	2	5.0	PL, DH
Grenadines			
Bequia Island	13	225.5	RS, TH
Canouan Island	2	10.0	PL, SI
Union Island	2	11.5	PL
Petit Nevis Island	1	6.0	SI
Carriacou			
Hillsborough	2	34.0	RS
Tyrell Bay	4	50.5	AN, SA, TH
Grenada			
Grand Anse Bay	1	10.0	RS
Black Bay	3	28.0	PL, DH
Grand Mal Bay	1	11.0	Mixed
Halifax Bay	2	16.0	Mixed
Beau Sejour Bay	10	234.0	PL
St. George's Harbor	46	1,472.5	DH, PL
Outside St. George's	2	146.0	PL, DH, AN
St. Eloi Point	2	25.0	RS
Barbados			
Carlisle Bay	2	4.0	SI
Deepwater Harbor	1	6.0	TH
Freshwater Bay	1	2.5	SI
Sandy Lane	2	19.0	SI
St. Martin			
Baie Grand Case	1	2.0	SI
Marigot Baie	1	0	—
St. Barthélemy			
Grand Saline Baie	1	0	—
Barbuda			
Palmetto Point	1	16.0	PL
Guadeloupe			
La Grand Baie	1	1.0	SI
Dominica			
Prince Rupert Bay	2	18.0	AN, PL
Layou River	1	5.5	AN

	Station	Buckets	Dominant species
Martinique			
Fort-de-France	6	33.5	AN
Grande Anses d'Arlet	4	35.0	SA, SI, RS
St.-Pierre	2	13.0	RS
St. Lucia			
Anse Choiseul	2	30.0	PL, TH
Caraibe Point	1	5.0	SA
Castries Harbor	2	0.5	AN
Gros Islet Bay	1	0.5	Mixed
Marigot Bay	3	14.5	AN
Petit Trou	1	0	—
Roseau Bay	3	88.5	SA, TH
Soufrière Bay	1	25.5	SI
Vieux Fort	5	13.5	TH
Tobago			
Great Courland Bay	1	1.0	—
Man-of-War Bay	4	89.0	RS
Rockly Bay	1	3.0	PL
Trinidad			
Chaguaramas Bay	11	1,055.0	SA, TH
Chupara Bay	4	247.0	SA
Port of Spain Harbor	3	50.0	PL
Las Cuevas Bay	1	6.0	PL
Lampara Net			
Jamaica			
East Kingston	2	52.0	AN
Lime Cay	1	15.0	SI
Port Royal	1	0	—
Dominican Republic			
Bahía de Ocoa	2	125.0	PL, TH
Boca del Yuma	1	0	—
Saona Island	1	0	—
Jamaica			
Lime Cay	1	12.0	DH
Long Bay	1	8.0	AN
Negril Harbor	2	2.0	AN
Pigeon Island	1	70.0	DH
Port Antonio	1	4.0	SI
Port Royal	1	10.0	AN
Port Royal Cays	3	102.0	DH, SI
Port Royal Mangrove	1	45.0	AN
Dominican Republic			
Bahía de Semana	2	30.5	AN
Venezuela			
Islas Los Roques	1	87.0	SI
Curaçao			
Plaza Abao	2	5.0	RS
Portanare Bay	1	3.5	SI

[1]AN = anchovy (Engraulidae)
DH = dwarf herring (*Jenkinsia*)
PL = pilchards (*Harengula*)
RS = round scad (*Decapterus*)
SA = sardine (*Sardinella*)
SI = silversides (Atherinidae)
TH = thread herring (*Opisthonema*)

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MFR PAPER 1085

Results of Troll Fishing Explorations in the Caribbean

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ABSTRACT—Exploratory and experimental troll fishing or "towing" was accomplished by all three project vessels, Alcyon, Calamar, *and* Fregata, *during the project period. During most of Phase I (1966-1969) this effort was incidental. In May of 1969 and subsequently, specific cruises were either wholly or partially devoted to trolling.*

Trolling explorations took place in the waters around Jamaica, around the banks north of Hispaniola, throughout the Lesser Antilles, and along the South American continental shelf down to lat.8°30'N. Experimental work included studies of lure preference; fishing depth; and line material, length, number, arrangement, and position. Vessel trolling speeds and the catch by time of day were investigated. Incidental trolling accomplished during Project Phase II is noted.

Summaries of catch rate data show a seasonal availability of troll-caught pelagic fish in the eastern Caribbean which begins very early in the year, rises to a peak during May, then falls off abruptly until the end of the year. This tendency is most pronounced on the banks in the northern Leeward Islands. The total weight of fish caught during cruises where trolling was a major portion of the effort was just over 28,000 pounds. Blackfin tuna (Thunnus atlanticus) *made up 37 percent of the total, great barracuda* (Sphyraena barracuda) *16 percent, and little tunny* (Euthynnus alleteratus) *13 percent. All tunas as a group (blackfin, little, yellowfin, and skipjack) made up over 60 percent of the catch by weight. Trolling has displayed only slight success in harvesting the pelagic resources in the Caribbean.*

Trolling or "towing" as it is generally called in the West Indies involves a moving vessel dragging one or more lines behind it; some form of hook and lure combination is attached to these lines. The motion of the lure causes the fish to strike it and become hooked. The line is then retrieved, the fish removed, and the line trailed out again. The method has been in use for a long period and is today practiced in the project region mostly by fishermen on islands possessing narrow shelf edges. These trolling efforts are conducted almost entirely by very small boats towing only two to four lines.

Prior to the project's efforts, only a small amount of offshore trolling using larger vessels had been conducted. Whiteleather and Brown (1945) trolled six lines from a 77 foot LOA(length overall) modified U.S. west coast purse seiner in the vicinity of Trinidad and Tobago and obtained good results—up to nearly 200 pounds/hour off Tobago. Off Jamaica, Oswald (1963) reported catches of up to 200 pounds

a day taken by the Jamaica Fisheries Division vessel *Bluefin*.

With these encouraging results, the Caribbean Fishery Development Project began trolling activities which were only incidental to other fishing activities during the project's Phase I (1966-69). The results of this incidental trolling were summarized by Yesaki (1969). He reported that about two-thirds of the incidental troll catch was taken above lat.15°N and that blackfin tuna[1] accounted for nearly one-third of all fish caught. During the Phase I period, the Jamaica Fisheries Division research vessel *Bluefin* had observed an overall catch rate of 67 pounds per fishing hour during nine cruises on various banks around Jamaica from August to December 1967.

At the beginning of the project's Phase II (September 1969 to July 1971) more emphasis was placed on troll fishing. Two objectives were set:

1. To explore, insofar as possible, the project region to determine the availability of surface pelagic species to troll fishing.
2. To test various types and arrangements of trolling gear and to determine their effect on fish availability.

VESSELS AND GEAR

All three project vessels were used in this work. *Calamar* and *Alcyon* are sister ships built in Japan in 1966.[2] These two ships have large well decks and small stern areas. *Fregata* was built in England in 1967.[2] This vessel is similar in design to the U.S. west coast salmon troller and was rigged in a similar fashion.

All vessels were fitted with trolling outriggers that varied in length and design from ship to ship. *Fregata*'s outriggers were 30 feet long and made up of sections of steel pipe, starting with a 3 inch pipe at the butt and tapering down to 1½ inches at the tip. These outriggers were mounted approximately at midship and held out by a stiff arm attached between the deckhouse and a point about one-third of the way out from the butt. Guy lines and a topping lift were then attached close to the outer tip of the pole and secured fore, aft, and to the masthead. Stabilizers were also fitted. *Alcyon*'s outrigger poles were rigged in a similar manner but were 35 feet long and made of 2½-inch pipe from butt to tip and mounted aft of the fo'c'sle on top of the bulwark. Outriggers designed specifically for trolling were not fitted on *Calamar*. From the port side of the vessel, a 15-foot boom which had been installed for towing plankton nets was used in trolling, and on the starboard side, a wooden pole of about the same length was fitted. *Fregata* and *Alcyon* could tow three to four lines from each of the poles, while *Calamar* was limited to two lines per outrigger.

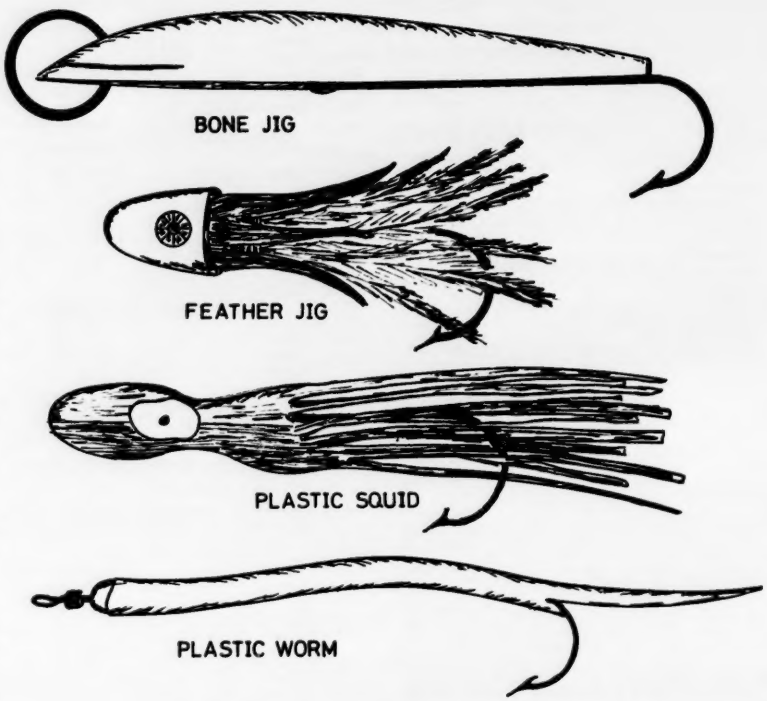

Figure 1.—Various lures used during project trolling exploration.

Three hydraulic trolling gurdies were fitted both port and starboard on *Fregata* in 1970. Two of the spools on each set were of 10-inch diameter and one on each set was 12 inches. These larger spools were intended for deep subsurface trolling, while the standard size reels were for surface trolling. These gurdies were found to be much slower in retrieving lines than the hand-over-hand method and were used only experimentally.

The total number of trolling lines used on each vessel and the rigging of these lines varied over the period of explorations. *Fregata* and *Alcyon* could tow as many as 11 lines, while *Calamar* was limited to 7 lines due to the short outriggers. The rigging used on these lines can be described for three different arrangements. The first arrangement was a tagline of 5/32-inch stainless steel cable fastened to the outrigger at one end and attached to a snubber of shock cord at the other end. The mainline, made of ⅛-inch Kuralon[3] 20 to 35 fathoms long, was attached to the snubber by an A/K snap. A leader of 0.045-inch × 2-feet stainless steel was then attached to the mainline with a 4/0 snap swivel terminating with the lure. The second and least sophisticated arrangement was a 3/16-inch polypropylene cord tied into the line 3 or 4 feet down from the outrigger, and a 2 foot steel leader with a lure was then connected to the mainline with a snap swivel. These lines were also from 20 to 30 fathoms in length. The final and what appeared to be the most efficient line rigging consisted of a length of ¼-inch poly-

[1]Scientific names of all fish represented in exploratory trolling catches are given in Table 2.

[2] See paper by Wolf and Rathjen, this number, for photographs and specifications.

[3] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

propylene line extending back from the outrigger to a point in line with the stern of the vessel. A 4/0 standard snap swivel was then attached. From the swivel either the mainline of 50 to 500 pound test monofilament was fastened or links of ¼-inch chain or a lead ball was connected between the tagline and mainline. The chain or ball was used to carry the lines slightly below the surface. In most cases no leader was used; the lure was attached directly to the mainline. Stern lines were rigged similarly to the outrigger lines except that taglines were eliminated.

A variety of lures were evaluated for suitability in the Caribbean area. These included bone and feather jigs of different sizes plus various types of plugs, flashers, spinners, and plastic worms (Fig. 1). Mustad double hooks in sizes 4/0, 6/0, and 8/0 were used most of the time. Barbless hooks were also tried, but it was decided that too many fish were lost because of them, and they were abandoned after a short period. Only artificial lures were used in order to make the method free of the need to divert valuable fishing time to obtaining natural bait. No assessment of the effectiveness of artificial versus natural lures was made. On the basis of the results of incidental trolling, it was decided to aim our trolling operations at the tuna group—blackfin, little tunny, skipjack, and yellowfin—as representative of the most promising portion of the resource. Initial gear arrangements and lure selections were made with this in mind.

SURVEY EFFORT

The normal technique during a cruise was to troll along the bank or shelf slopes holding generally to the 100-fathom depth sounding. Where the edge was precipitous, the vessel zigzagged on and off the edge. A small proportion of time was spent trolling in very deep water or over the bank proper when conditions (bird flocks, etc.) warranted. Whenever concentrations of fish were encountered, the vessel would fish the immediate area until biting diminished before continuing on.

During most of the explorations gear experimentation of some sort also took place. Original planning called for early experimental efforts giving rise to a standard trolling arrangement that would be used throughout the remainder of the work, but due to a scarcity of fish caught this was not achieved until near the end of the work.

Between May 1969 and June 1971, most of the banks and waters adjacent to islands had undergone some exploration into their trolling potential. The areas explored stretched from west of Jamaica, east to the northern Leeward Islands, then south through the Windward Islands to about lat.8°30'N. The project region was divided into five areas for purposes of this report (Fig. 2):

1. Jamaica south and southwestern waters.
2. Waters adjacent to Hispaniola and Puerto Rico south to lat.15°00'N.
3. The Leeward Islands.
4. The Windward Islands.
5. Trinidad and the northeastern South American shelf.

In Table 1, the major exploratory trolling efforts in ship hours by month and area are given. Area III received the greatest proportion of effort because of the relative success there. Areas I and IV received high proportions because of their proximity to operational bases (*Alcyon* in Jamaica and *Fregata* and *Calamar* in Barbados). Many factors were considered in the planning of a cruise to a particular location. Among these were the expected abundance of fish, results of incidental trolling, vessel operational limitations, gear experimentation, and extent of geographical coverage of the region.

The units of fishing effort are the ship hour and line hour. The former is the number of hours that the ship explored a given area, while the latter is the product of the number of ship hours times the number of lines towed.

RESULTS

Species Composition

Common and scientific names for all species identified from troll catches are given in Table 2.

The species compositions of the catches from all cruises where trolling was a major fishing effort are given in Table 3. In Areas I and II, the pattern is generally similar. Barracudas dominate the catches in both numbers and pounds. When the four tuna species are grouped together, they comprise a good proportion of the total in both areas. In Area II, wahoo make up about one-fourth of the total weight, but only 7 percent of the numbers. This is due mostly to *Alcyon* cruise 70-1 (January) when 17 wahoo caught averaged over 42 pounds each. In Area III, blackfin tuna make up nearly half of the total catch by weight and numbers. The tunas as a group constitute over three-fourths of the total by weight and over 80 percent by number. No other species make significant contributions to the totals. Blackfin tuna make up about one-fourth of the catch by weight and 30 percent by

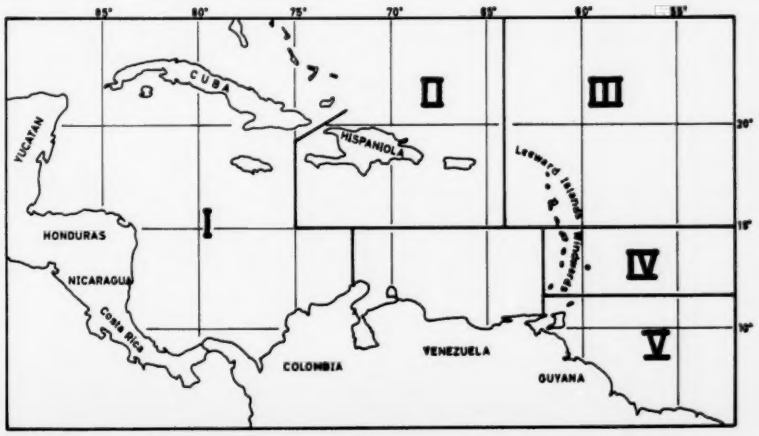

Figure 2.—Caribbean Fisheries Development Project region showing areas where exploratory trolling was conducted.

Table 1.—Ship hours of effort expended trolling by area and month.

Area I			Area II			Area III			Area IV			Area V		
Month	Year	No. hrs.	Month	Year	No. hrs.	Month	Year	No. hrs.	Month	Year	No. hrs.	Month	Year	No. hrs.
Sept.	69	120	Jan.	70	92	May	69	99	July	70	98	Sept.	70	22
Oct.	69	124	Nov.	70	39	Aug.	69	99	Sept.	70	91	Oct.	70	75
Feb.	70	17	May	71	35	Nov.	69	27	Nov.	70	97	Feb.	71	19
—	—	—	June	71	41	Dec.	70	97	Feb.	71	84	—	—	—
—	—	—	—	—	—	Mar.	71	125	Mar.	71	78	—	—	—
—	—	—	—	—	—	Apr.	71	30	May	71	59	—	—	—
—	—	—	—	—	—	June	71	151	—	—	—	—	—	—
Total		261			207			628			507			116
Percent		15.2			12.0			36.5			29.5			7

Table 2.—Common and scientific names of troll caught fish.

Accepted Common Name	Other Name	Scientific Name
Blackfin tuna	bonito	*Thunnus atlanticus*
Little tunny	false albacore	*Euthynnus alletteratus*
Yellowfin tuna	albacore	*Thunnus albacares*
Skipjack tuna	—	*Katsuwonus pelamis*
Great barracuda		*Sphyraena barracuda*
Dolphin		*Coryphaena hippurus*
Rainbow runner	tapio	*Elagatis bipinnulata*
Wahoo	kingfish	*Acanthocybium solanderi*
King mackerel	kingfish	*Scomberomorus cavalla*
Cero	spanish mackerel	*Scomberomorus regalis*
Horse-eye jack		*Caranx latus*
Green jack	blue runner	*Caranx crysos*
Greater amberjack	almaco jack	*Seriola dumerili*
Frigate mackerel		*Auxis thazard*
Triplefail		*Lobotes surinamensis*
Requiem Sharks		Carcharhinidae

Table 3.—Species composition of exploratory trolling cruises by area and month. (Figures in parentheses are percentages.)

Cruise	Area	Month-Year	Blackfin tuna		Little tuna		Yellowfin tuna		Skipjack tuna		Barracuda		Dolphin (fish)		Rainbow runner		Wahoo		King mackerel		Cero		Others		Total	
			No.	Lbs.	No.	Lbs.	No.	Lbs.	No.	Lbs.	No.	Lbs.	No.	Lbs.	No.	Lbs.	No.	Lbs.	No.	Lbs.	No.	Lbs.	No.	Lbs.	No.	Lbs.
A[1]69-9	I	Sept. 69	44	202	1	9	—	—	44	544	73	542	16	85	9	47	4	127	—	—	2	7	6	10	199	1,573
A59-10	I	Oct. 69	27	107	4	16	—	—	4	45	135	715	4	40	11	47	1	30	—	—	1	4	18	10	205	1,014
A70-2	I	Feb. 70	2	14	—	—	—	—	—	—	22	148	—	—	—	—	6	54	—	—	—	—	—	—	30	216
		Totals	73	323	5	25	—	—	48	589	230	1,450	20	125	20	94	11	211	—	—	3	11	24	20	434	2,803
		Percent	(16.8)	(11.5)	(1.2)	(0.1)	—	—	(11.1)	(21.0)	(53.0)	(50.1)	(4.6)	(4.4)	(4.6)	(3.4)	(2.5)	(7.5)	—	—	(0.7)	(0.4)	(5.5)	(0.7)	(100.0)	(100.0)
A70-1	II	Jan. 70	37	269	6	22	—	—	1	5	132	1,207	12	123	4	23	17	715	2	45	11	84	6	28	228	2,521
A70-11	II	Nov. 70	12	131	6	24	—	—	—	—	38	392	18	75	12	60	3	55	—	—	1	4	5	21	95	762
A71-4	II	May-Jun. 71	11	72	5	23	—	—	—	—	14	82	6	101	—	—	7	154	1	6	3	13	7	36	54	487
		Totals	60	472	17	69	—	—	1	5	184	1,681	36	299	16	83	27	924	3	51	15	101	18	85	377	3,770
		Percent	(15.9)	(12.5)	(4.5)	(1.8)	—	—	(0.3)	(0.1)	(48.8)	(44.6)	(9.5)	(7.9)	(4.2)	(2.2)	(7.2)	(24.5)	(0.8)	(1.4)	(4.0)	(2.7)	(4.8)	(2.3)	(100.0)	(100.0)
C[2]69-5	III	May 69	639	4506	299	1226	31	898	16	75	37	111	35	497	13	56	3	25	19	151	10	44	—	—	1,102	7,589
C69-9	III	Aug. 69	227	1262	64	280	1	6	31	125	24	60	3	21	18	94	3	105	2	22	1	8	6	33	380	2,016
A69-11	III	Nov. 69	8	53	7	30	—	—	1	8	14	70	3	13	—	—	3	125	1	10	—	—	—	—	37	309
F[3]70-11	III	Dec. 70	75	436	63	285	—	—	3	19	—	—	26	261	1	3	1	6	2	20	8	23	—	—	179	1,053
F71-2	III	Mar. 70	161	1021	195	780	—	—	2	12	53	306	32	296	22	86	7	201	2	28	9	31	3	19	486	2,780
C71-6	III	Apr. 71	200	526	55	223	5	41	1	5	32	159	14	199	8	31	—	—	4	22	—	—	—	—	319	1,206
C71-8	III	Jun. 71	268	1426	134	596	47	587	49	437	60	304	1	3	78	440	10	311	18	263	9	43	1	7	675	4,417
		Totals	1578	9230	817	3420	84	1532	103	681	220	1,010	114	1,290	140	710	27	773	48	516	37	149	10	59	3,178	19,370
		Percent	(49.7)	(47.7)	(25.7)	(17.7)	(2.6)	(7.9)	(3.2)	(3.5)	(6.9)	(5.2)	(3.6)	(6.7)	(4.4)	(3.7)	(0.9)	(4.0)	(1.5)	(2.7)	(1.2)	(0.8)	(0.3)	(100.0)	(100.0)	
F70-7	IV	July 70	13	87	—	—	—	—	—	—	15	78	1	22	—	—	1	8	—	—	—	—	—	—	30	195
F70-8	IV	Sept. 70	—	—	—	—	—	—	1	6	10	36	1	7	—	—	3	53	—	—	—	—	—	—	15	102
F70-10	IV	Nov. 70	29	139	2	7	7	26	3	9	22	100	4	14	1	4	1	1	—	—	—	—	—	—	69	300
F71-1	IV	Feb. 71	9	32	2	12	—	—	1	9	32	102	—	—	5	25	2	55	—	—	—	—	—	—	51	235
F71-3	IV	Mar. 71	31	222	—	—	9	55	13	77	9	28	1	6	3	15	5	125	1	18	—	—	3	7	75	554
F71-4	IV	May 71	—	—	1	4	—	—	—	—	3	21	5	86	—	—	34	447	—	—	—	—	—	—	43	558
		Totals	82	480	5	23	16	81	18	101	91	365	12	135	9	44	46	689	1	19	—	—	3	7	283	1,944
		Percent	(29.0)	(24.7)	(1.8)	(1.2)	(5.7)	(4.2)	(6.4)	(5.2)	(32.2)	(18.8)	(4.2)	(6.9)	(3.2)	(2.3)	(16.3)	(35.4)	(0.43)	(1.0)	—	—	(1.1)	(0.7)	(100.0)	(100.0)
F70-8	V	Sept. 70	—	—	—	—	—	—	—	—	—	—	1	3	—	—	—	—	—	—	—	—	—	—	1	3
F70-9	V	Oct. 70	6	17	1	2	—	—	—	—	15	97	—	—	—	—	1	7	—	—	—	—	—	—	23	123
F71-1	V	Feb. 71	1	3	2	13	—	—	—	—	—	—	9	91	—	—	2	64	—	—	—	—	—	—	14	171
		Totals	7	20	3	15	—	—	—	—	15	97	10	94	—	—	3	71	—	—	—	—	—	—	38	297
		Percent	(18.4)	(6.7)	(7.9)	(5.1)			—	—	(39.5)	(32.7)	(26.3)	(31.6)	—	—	(7.9)	(23.9)	—	—	—	—	—	—	(100.0)	(100.0)
		Regional Totals	1800	10525	847	3552	100	1613	170	1,376	740	4,558	192	1,943	185	931	114	2,668	52	586	55	261	55	171	4,310	28,184
		Percent	(41.8)	(37.3)	(19.7)	(12.6)	(2.3)	(5.7)	(3.9)	(4.9)	(17.2)	(16.2)	(4.5)	(6.9)	(4.3)	(3.3)	(2.6)	(9.5)	(1.2)	(2.1)	(1.3)	(0.9)	(1.3)	(0.6)	(100.0)	(100.0)

[1]A = Vessel *Alcyon*.
[2]C = Vessel *Calamar*.
[3]F = Vessel *Fregata*.

Table 4.—Catch rate in pounds per trolling hour and pounds per line per hour by cruise, area, and month.

Cruise	Area	Month-Year	Pounds of fish	Ship trolling hours	Line hours	Lbs/hour	Lbs/ Line hour
A[1]69-9	I	Sept. 69	1,573	120	788	13.1	2.0
A69-10	I	Oct. 69	1,014	124	744	8.2	1.4
A70-2	I	Feb. 70	216	17	108	12.7	2.0
Total			2,803	261	1,640	10.7	1.7
A70-1	II	Jan. 70	2,521	90	529	23.0	4.8
A70-11	II	Nov. 70	762	39	213	19.5	2.8
A71-4	II	May-Jun. 70	487	76	702	6.4	0.7
Total			3,770	205	1,444	18.4	2.5
C[2]69-5	III	May 69	7,589	99	592	76.7	12.8
C69-9	III	Aug. 69	2,016	99	594	20.4	3.4
A69-11	III	Nov. 69	309	27	169	11.4	1.8
F[3]70-11	III	Dec. 70	1,053	97	970	10.9	1.1
F71-2	III	Mar. 71	2,780	125	1,250	22.2	2.2
C71-6	III	Apr. 71	1,206	30	150	40.2	8.0
C71-8	III	Jun. 71	4,417	151	1,057	29.3	4.2
Total			19,370	628	4,782	30.8	4.1
F70-7	IV	July 70	195	98	490	2.0	0.4
F70-8	IV	Sept. 70	102	91	637	1.1	0.2
F70-10	IV	Nov. 70	300	97	970	3.1	0.3
F71-1	IV	Feb. 71	235	84	840	2.8	0.3
F71-3	IV	Mar. 71	554	78	780	7.1	0.7
F71-4	IV	May 71	558	59	590	9.4	0.9
Total			1,944	507	4,307	3.8	0.5
F70-8	V	Sept. 70	3	22	144	0.1	0.07
F70-9	V	Oct. 70	123	75	525	1.6	0.2
F71-1	V	Feb. 71	171	19	190	9.0	0.9
Total			297	116	859	2.4	0.3
Regional total			28,184	1,717	13,032	16.4	2.2

[1]A = Vessel *Alcyon*. [2]C = Vessel *Calamar*. [3]F = Vessel *Fregata*.

number in Area IV. The tuna group is about equal in weight contribution to that of wahoos, but they contribute a much greater number. Barracudas are the most numerous species. From the relatively few fish caught in Area V, barracudas are again most numerous, but are about equal in weight to dolphin fish. Wahoos again make up an important proportion of about one-fourth of the weight. Since the regional totals are so dominated by catches from Area III, a resume of species composition for the region as a whole is meaningless.

Catch Rates

The trolling catch rates in pounds/ship hour and pounds/line hour are given in Table 4. The highest catch rate was observed on *Calamar* cruise 69-5 in Area III during May 1969 when nearly 77 pounds per ship hour and 13 pounds per line hour were caught. Area III displayed the highest consistent catch rates and also the highest average at about 31 pounds per ship hour. The average catch rate observed in Area III was in excess of the rates observed on any cruise in any of the other areas.

When the catch rates are plotted by the month when they were observed an indication of seasonal availability is obtained (Fig. 3). Sufficient data to present a seasonal evaluation were available for Areas III and IV only, but both reflect the same general pattern of highest availability during the second quarter of the year and relatively low levels during the first, third, and fourth quarters.

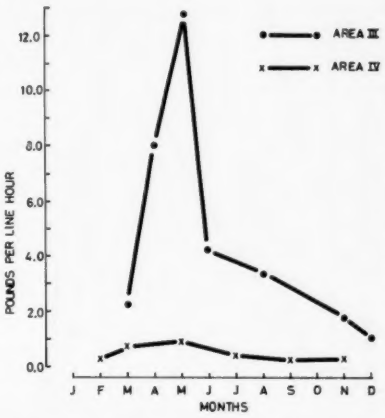

Figure 3.—Trolling catch rate variation by month.

Gear Experimentation

During most of the trolling explorations various kinds, lengths, and arrangements of trolling lines and types and sizes of lures were tested to evaluate their effect on catch rate.

Lure preference

During *Alcyon* cruises 69-9 and 69-10 conducted on the banks around Jamaica (Area I) during September and October 1971, complete records on the catch of various types and sizes of lures were kept. Red/white and yellow/white feather jigs were compared with bone jigs and plastic bodied and skirted squids. In Table 5 the lure preference data are summarized. Overall, red/white feather jigs were found to be superior to the other types used. Considering the most numerous species as separate groups the barracuda were nearly evenly divided in preference between yellow/white feather jigs and bone jigs, but displayed a definite lesser preference for red/white feather jigs and plastic squids. In contrast, the tunas as a group overwhelmingly preferred red/white feather jigs.

Table 5.—Lure type preference.

Fish Species	Numbers of fish caught: Red/White feather jigs	Yellow/White feather jigs	Bone jigs	Plastic squid
Barracuda	56	46	59	9
Blackfin tuna	45	9	10	2
Skipjack tuna	29	7	5	6
Little tuna	3	1	—	—
Rainbow runner	11	4	3	1
Dolphin	11	1	1	3
Jacks	5	3	1	—
Mackerels	2	1	—	—
Wahoo	3	1	1	—
Total fish	165	73	80	21
Hours trolled	323.5	172.8	231.6	71.3
All fish/ hour	0.51	0.42	0.35	0.29
Barracuda/ hour	0.17	0.27	0.25	0.13
All tuna/ hour	0.24	0.09	0.06	0.11

When examining the catch of barracudas and of all tunas by lure size (see below), it is evident that when barracudas took feather jigs they preferred the larger size, while the tunas preferred the smaller.

	3 ounce feather jig	6 ounce feather jig
Barracuda	0.09[1]	0.45
All tunas	0.32	0.19

[1]Number of fish caught per lure/hour of trolling.

During cruises conducted by *Fregata* in 1970, attention was paid to lure preference, but results were inconclusive due to a scarcity of fish caught. Beginning with cruise 70-11, *Fregata* used all small sized red/white or all white feather jigs during nearly all the

subsequent trolling cruises. The decision was based on their performance with the tuna group during previous *Alcyon* work and the preference of a commercial tuna troll fisherman consultant to the project from the west coast of the United States. This pattern was varied only once during two days' fishing on *Fregata* cruise 71-1, when white plastic worms were directly compared with white feather jigs. The results are shown below.

	White plastic worms	Jigs
Barracuda	0.03[1]	0.16
All tunas	0.02	0.06

[1]Number of fish caught per lure/hour trolling.

Again feather jigs were shown to be the most effective.

Trolling line variations

Material.—Monofilament trolling lines were found to be most satisfactory. They created less drag than braided cotton or synthetic line of comparable strength, were more difficult for fish to see in the water, had built-in strike shock absorption, and a greater range of breaking strengths were readily available. One disadvantage was that monofilament was more difficult to hand-retrieve than a larger diameter line would have been. Experience showed, however, that its advantages considerably outweighed its disadvantages.

Number of lines.—During this work there were no specific experiments aimed at determining the effect of a differing number of trolling lines on the catch rate. Although the number of lines used by any of the vessels did vary somewhat, the changes usually took place between cruises and not during them. There was, however, ample visual evidence that a positive correlation existed between the catch and the number of lines. The tuna group, which constituted the largest proportion of the overall catch, displayed a marked tendency to strike all lines almost simultaneously when a school was encountered. This was particularly true during the first encounter but was evident even after repeated encounters. Even when a variety of lures was being towed, the same phenomenon occurred, but lure selectivity became evident after the first encounter. Catches of species other than tunas were more random and were probably the result of factors other than the number of lines towed.

Line length.—Originally all the vessels were using trolling lines of not less than 25 fathoms. When more than six lines were streamed these had a tendency to cross and foul during a turn. Through experimentation and advice from consultants, an arrangement of line lengths was worked out with a maximum length of 30 fathoms down to as short as 3 fathoms from the stern. These variable line lengths allowed an increase in the number of lines towed while decreasing line fouling problems but still retaining catching efficiency. The longer lines caught a larger number of fish in areas of low productivity in that the occasional strike would be on the longer lines, but in areas of fish concentrations line length was not critical, and all lines would hook fish at about the same rate. This arrangement was used throughout all *Fregata* trolling efforts

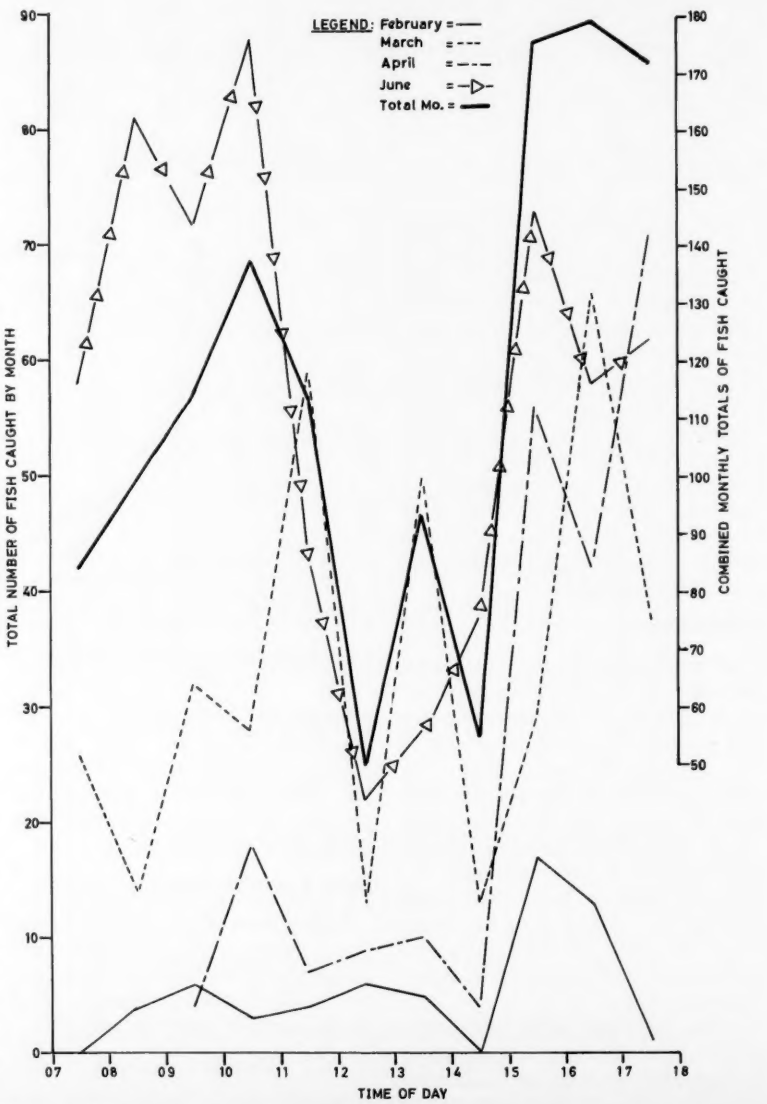

Figure 4.—Trolling catch in Area III (northern Leeward Islands) by time of day for the months indicated.

in late 1970 and on *Fregata* cruise 71-1.

Cruise	Line Length 3-10 fathoms	11-20 fathoms	21-30 fathoms	31 + fathoms
71-1	24.4[1]	69.3	74.0	—
71-3	—	8.4	7.2	5.0

[1]Number of fish caught per line.

When cruise 71-2 was completed, the results showed a higher catch rate for lines in the 11-20 and 21-30 fathom length range. The line arrangement was altered for cruise 71-3 when lines of under 10 fathoms were eliminated and lines in excess of 30 fathoms added. The results during cruise 71-3 show an almost even distribution of catch between the three length groups and this length arrangement was used by all vessels throughout the remainder of project trolling explorations.

Line Location.—During *Fregata* cruise 71-2 when the arrangement of line lengths on each side of the vessel was the same and all lines used the same lure (red/white feather jig - 1½ ounces); there was a decided superiority in the catch by lines on the port side of the vessel over lines on the starboard side.

Species	Port	Starboard	Ratio (port to starboard)
Barracuda	40[1]	18	2.2 : 1
All tuna	225	127	1.8 : 1
Other species	40	28	1.4 : 1
Total	305	173	1.8 : 1

[1]Number of fish caught.

Line Arrangement.—During *Fregata* cruise 71-2 the two 21-fathom lines located one in from the end of each trolling outrigger caught nearly one-third of all the fish caught by all 10 lines during the cruise. This is an indication, at least, that there is some effect on the position of the trolling line in the arrangement.

Vessel speed

No direct observations were made of the effects of vessel speed on catch. Incidental trolling was always conducted at the vessel's cruising speed, while regular exploratory trolling was all done at about 6 knots. This speed was considered adequate for tuna species, but not so fast as to preclude catching other species.

Time

On all trolling cruises in 1971, detailed records were kept for the time of day when fish were caught. Through these observations, it was established during what period(s) of the day the greatest fish biting activity was encountered. It would be presumptuous to state the periods of greatest fish activity for all areas due to the sparseness of data taken as to time of day; however, Area III (northern Leeward Islands) appears to have enough data to produce a reliable picture of greatest fish activity.

As can be seen in Figure 4, there are two periods of increased fish biting during the day; one in mid to late morning and another in mid to late afternoon, which is more pronounced. This pattern appears during all the months shown except the line representing the month of June. This variation can be explained by observing the fish catch from Gibbs Seamount separately from the remainder of Area III. Gibbs Seamount is a small bank located at lat.16°33'N, long.63°56'W or approximately 37 miles south-southwest of Saba Bank. The distance to this area from the nearest land is too great for fishermen in the adjacent islands to utilize the bank; consequently, little or no fishing had been done there previous to our explorations. Two days of continuous fishing were accomplished there during June. The catch rate on the first day of fishing reached 108.2 pounds/ship hour, but dropped to 67.8 pounds/ship hour on the second day. This considerable drop in catch rate over such a short period of time indicates that the Gibbs Seamount area might be fished

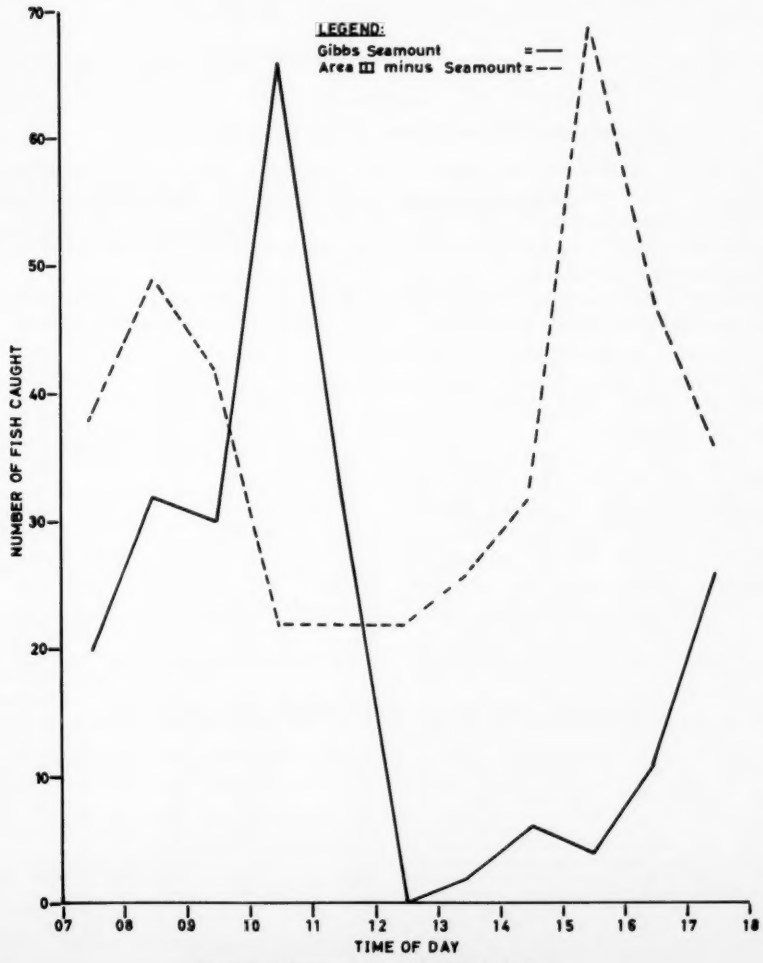

Figure 5.—Trolling catch for June 1971 in Area III.

out rapidly. Figure 5 shows a picture of Gibbs Seamount data with greatest fish activity in the morning between 1000 and 1200 hours. Area III is also plotted on this graph minus the Gibbs Seamount data. When the June data are plotted without the Gibbs Seamount data, the pattern of fish catch again becomes similar to that of the other months.

When these data are examined for the three major species in the catch, the pattern remains constant except that the two tunas appear to provide the bulk of the high afternoon catches (Fig. 6).

Incidental Trolling

During Phase II of the project incidental trolling was conducted during all cruises as it had been during Phase I. Incidental trolling usually consisted of two or three 30-fathom lines towed during daylight hours while the vessel was passing to or from other fishing areas. When a vessel was rigged for multiple line trolling it usually used all lines when in passage.

Only one instance of incidental trolling was noteworthy during Phase II. In September 1969, *Calamar* caught 10 yellowfin tunas weighing over 500 pounds in aggregate at lat.7°41'N, long.56°14.5'W or about 130 miles north-northwest of Paramaribo, Surinam. Many more larger fish were reported lost.

DISCUSSION AND CONCLUSION

An examination of the area catch rates indicates that only in Area III, and then only during April and May, was troll fishing considered capable of supporting independent offshore fishing by a vessel large enough for extended voyages of a week or more. These catch rates were calculated by averaging all locations explored during a cruise; however, there were places where the rate was higher. Specific locations where catch rates in excess of 5.0 pounds/line hour were observed are given in Table 6. It should be remembered however, that in most cases each of these locations displayed its high catch rate only on the occasion noted and did not display the same rates during other visits.

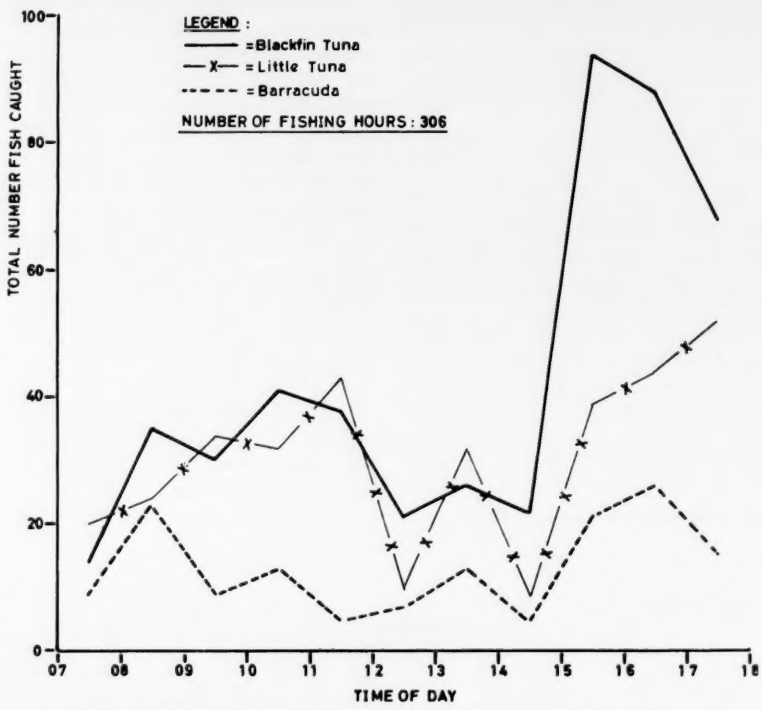

Figure 6.—Trolling catch in Area III of the most numerous species by time of day.

Exceptions to this are the edges of Anguilla Bank and Gibbs Seamount. Gibbs Seamount is a small, previously untouched bank lying about 35 miles south by west of Saba Bank that, because of its size, could not be expected to provide continuously good fishing. Conversely, Anguilla Bank is large and could be expected to provide the best continuous troll fishing of any location explored.

It is clear that many interrelated factors go toward determining the availability of fish to trolling gear in the Caribbean and particularly in Areas I and III. The first of these to become evident were lure type and size. Of the types tested, small feather jigs, particularly in red and white or all white, gave the best performance on the tuna group. This confirms results obtained by Oswald et al. (1969) in exploratory trolling efforts conducted around the islands of Nevis, St. Kitts, and Anguilla.

When examining line characteristics, long monofilament lines (20-30 fathoms) fished as far out on the port outrigger as possible appear to provide the most ideal circumstances for the highest catch rates. The reasons behind this are not fully apparent, but can be speculated upon.

There are likely to be two major factors involved in a fish becoming aware of a trolled lure. One is the visibility and the other would be turbulence caused by the passage of the lure through the water. Both of these factors would be negatively in-

Table 6. —List of locations by area and month showing highest troll catch rates.

Area	Location	Month	Pounds caught	Line hours	Catch rate (lbs./line/hour)
I	Morant Cays — South of Jamaica	Sept.	693	108	6.4
II	S.E. Mouchoir Bank — North of Hispaniola	Jan.	1,100	90	12.2
II	S. Mouchoir Bank — North of Hispaniola	Jan.	512	72	7.2
III	S.E. Anguilla Bank — Northern Leeward Is.	May	5,196	378	13.7
III	N. Anguilla Bank — Northern Leeward Is.	May	656	66	9.9
III	N.E. Anguilla Bank — Northern Leeward Is.	May	702	60	11.7
III	N. Saba Bank — Northern Leeward Is.	April	1,099	140	7.9
III	Gibbs Seamount — (16°32'N.-63°55'W.)	April	149	10	14.9
III	N.E. Anguilla Bank — Northern Leeward Is.	June	850	91	9.3
III	Gibbs Seamount — (16°32'N.-63°55'W.)	June	1,617	126	12.8
III	N. Anguilla Bank — Northern Leeward Is.	Mar.	1,183	220	5.4

fluenced by the effects of vessel and screw turbulence. The positive factors which appear to affect catches all have the effect of minimizing turbulence in the area of the lure. With longer lines fished farther out, the effect is obvious. Why catches should be better on the less turbulent port side of the vessel is not obvious until the effect of a right hand turning propellor creating more turbulence on the right or starboard side of the vessel is remembered.

The idea of less turbulence—more opportunity for fish biting—is strengthened by the inboard lines during a turn tending to catch more than the others because they are inside the vessel's turning circle and wake and the resultant turbulences. This is so established that our trolling vessels often zigzag when in a school to increase catches.

The value of knowing what time of day the fish are most likely to be caught trolling could be applied if trolling were to be combined with some other fishing operation, i.e., handlining or trap fishing, which could be conducted during the off peak trolling time.

In summary, troll fishing has displayed only slight success in harvesting the surface pelagic resources of the project region. Only the banks of the northern Leeward Islands, and these only during April and May, provided catch rates considered high enough to support troll fishing as an independent effort. As the method is already known in the West Indies and relatively inexpensive, if a vessel must travel to suitable offshore grounds for other types of fishing, it can be a good secondary method during slack periods of handlining (mechanical reel) and trap fishing for snapper and related species.

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MFR PAPER 1086

Spiny Lobster Fishing Explorations in the Caribbean

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ABSTRACT—The Caribbean Fishery Development Project vessel Alcyon *devoted four cruises toward assessing the spiny lobster resources of Pedro Bank and other small banks south of Jamaica; Mouchoir, Silver, and Navidad Banks north of Hispaniola; Saba, Anguilla, Barbuda, and other small associated banks in the northern Leeward Islands. This work was undertaken as a consequence of good incidental lobster catches having been made during pot fishing explorations for snappers and related demersal species in the northern half of the project region.*

The exploratory technique applied consisted of an echo sounder survey of the bottom followed by try net trawling to assess the abundance and locate areas of concentration, after which lobster pots would be set to obtain catch rate data. The try trawling was abandoned after one cruise because of generally unsuitable trawling grounds in the places explored. Fish pots were also set alongside lobster pots on occasion for comparison.

Lobster catches were extremely low and only the western end of Pedro Bank displayed commercial potential with a catch rate of 0.45 lobster per pot.

INTRODUCTION

The Caribbean Fishery Development Project devoted four exploratory/experimental cruises to assessing the abundance of spiny lobster[1] (*Panulirus argus*) in the northern half of the project region, from February to July 1971. Good incidental catches of lobsters during fish-pot fishing explorations in these areas and the high economic demand for their meat were the primary reasons for this work, but the high success of recent exploratory fishing surveys off Honduras and Nicaragua (Yesaki and Guidicilli[2]) was also considered. It was decided that the exploratory techniques (including echo sounding, trawl netting, and pot fishing) used during this latter work would be experimentally attempted in our project region.

Some exploratory lobster fishing had been conducted earlier in other parts of the project region. During a general resources survey of Trinidad and Tobago by MV *Fregata* in 1968, a total of 144 lobster pot sets and 8 ice-can sets were soaked an average of 52 hours but yielded no lobsters.

[1] Referred to hereafter as spiny lobster or lobster.

[2] Yesaki, M., and M. Guidicilli. Summary of exploratory fishing operations of the RV *Canopus* in the western Caribbean Sea to June 1970. UNDP/FAO Central American Fishery Development Project, 46 p. (Unpubl. manuscr.)

On other occasions trammel nets set near the Grenadine Islands in the Windward Islands chain were also unsuccessful.

Between January and May 1971, the U.S. National Marine Fisheries Service provided a fishery consultant to help plan and direct lobster fishing operations.

AREAS OF EXPLORATION

During previous exploratory fishing using fish pots, spiny lobsters were caught incidentally on many occasions. A summary of these incidental catches is given in Table 1. It can be seen that most incidental lobster catches came from the northern half of the project region and the greatest proportion of these came from Pedro Bank south of Jamaica.

Alcyon devoted four exploratory and experimental cruises to spiny lobsters. During cruise 71-1 (23 February — 11 March 1971) parts of Pedro Bank were surveyed. Cruise 71-2 (23 March — 5 April) explored Navidad, Silver, and Mouchoir Banks north of Hispaniola. Other parts of Pedro Bank plus Albatross Bank, Eight Mile Bank, and the Morant Cays area were examined during cruise 71-3 (20 April — 6 May) (Fig. 1a). Saba, Barbuda, and Anguilla Banks plus other small associated banks received attention during cruise 71-5 (13-30 July) (Fig. 1b).

While most banks were given only a minimum of effort, Pedro Bank was explored much more thoroughly, as shown in Figure 2.

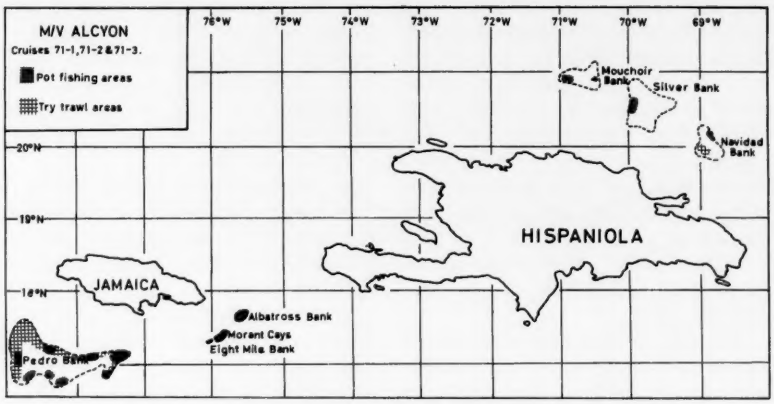

Figure 1a.—Banks south of Jamaica and north of Hispaniola where spiny lobster exploratory operations were conducted.

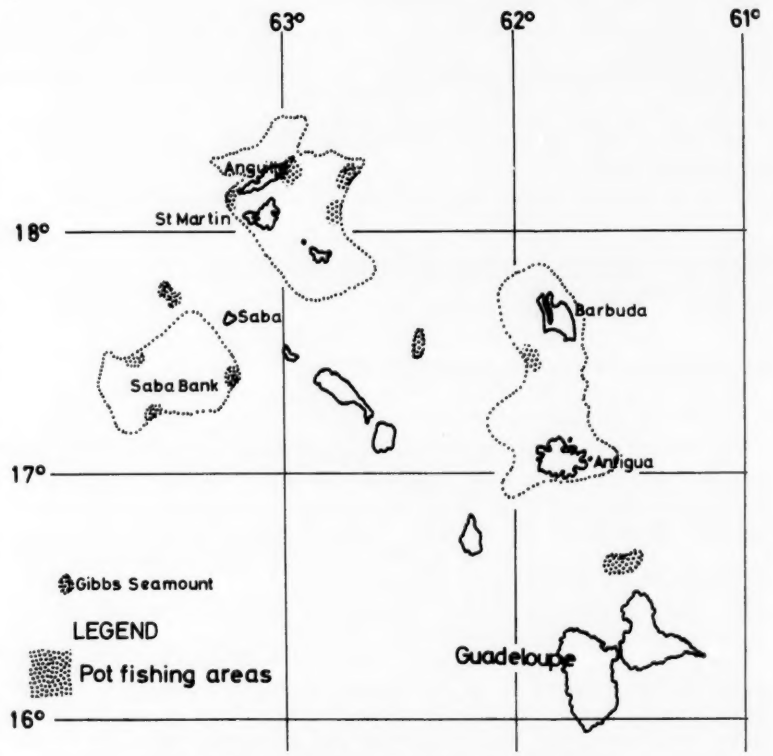

Figure 1b.—Leeward Islands Banks showing areas of pot fishing.

EXPLORATION METHODS

Survey Techniques

Initially the technique used consisted of a thorough researching of existing knowledge of the area. After the review of bathymetric charts and direct knowledge of the area, a series of transect lines were established. These lines were traversed using the echo sounder. When the bottom was considered smooth enough the lobster trawl was dragged for a short distance. If the results were positive, additional drags were made to locate the centers of abundance. Strings of lobster pots were then put at these centers of abundance in order to establish catch rates. This technique was used during cruise 71-1 and on Navidad Bank during cruise 71-2 before the trawling step was eliminated due to the scarcity of trawlable ground in the areas explored and lack of catch. The remainder of the explorations was conducted using just the echo sounder, followed by sets of lobster pots. A few fish pots of the same "Z" and "D" configurations used when lobsters were caught incidentally during explorations for snappers and other related demersal species were then added to assess their performance against the Nicaraguan lobster pot.

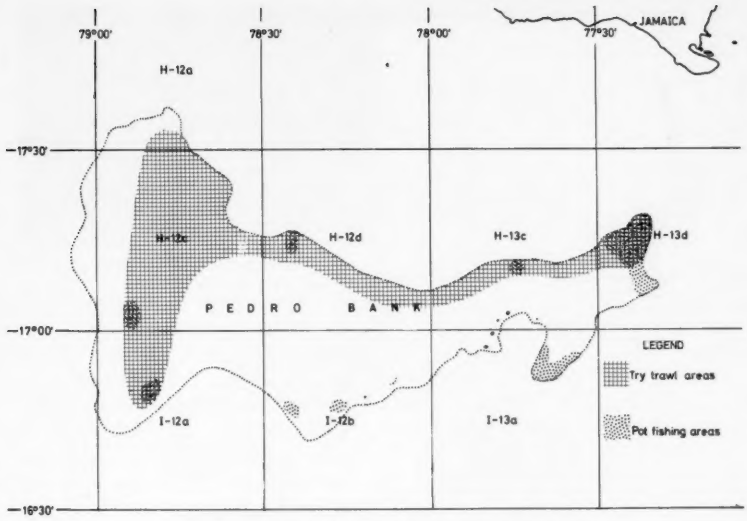

Figure 2.—Pedro Bank showing area of exploratory effort.

Table 1.—Summary of incidental lobster catches during fish pot explorations.

Vessel and Cruise	Area	No. of pot lifts	Lobster Catch (No - lb)
Alcyon			
69-11	Anguilla Bank	20	12 - 41.4
70-2	E. Pedro Bank	29	36 - 87.0
70-3	Albatross Bank	27	2 - 11.0
70-3	Anguilla Bank	42	5 - 18.0
70-4	E. Pedro Bank	174	357 - 960.5
70-6	Anguilla Bank	52	3 - 7.5
70-7	E. Pedro Bank	174	95 - 217.5
70-12	E. Pedro Bank	50	19 - 40.5
Calamar			
70-8	Anguilla Bank	15	2 - 6.5
71-1	Grenada Shelf	80	2 - 5.0
71-2	T'dad-Guyana	296	3 - 5.0

[1]Z and D pots (see Project Cruise Report No. 26, 29 July, 1970).

Fishing Gear and Handling

Lobster try trawl net

The lobster trawl used during explorations was 18-foot head-rope × 18-foot footrope, two-seam bottom-hugging net. It was constructed to the consultant's design with heavy weight 4-inch braided mesh nylon webbing. Details of construction are given in Figure 3. Steel trawl doors of V configuration, designed by the project staff, were used to spread the net (Fig. 4). The doors were attached to a 5 fathom ⅜-inch wire bridle which in turn was shackled to the ½-inch trawl wire.

Drags of 10 minutes duration were completed and timed from the braking of the winch to the start of retrieval. When the doors were hauled to the trawl block, the lazyline attached to the port door was hauled aboard, hooked to the hauling system on the main mast, and the cod-end winched aboard.

Lobster pots

The pots used were obtained from the UNDP/FAO (United Nations Development Program/Food and Agriculture Organization) Central American Fishery Development Project and are identical to lobster pots used in commercial lobster fishery centered at Corn Island, Nicaragua. They are constructed of 1-inch × 2-inch galvanized rectangular mesh wire of 14-18 B.W.G. (Birmingham Wire Gauge). Overall, they measured 2 feet × 2 feet × 1 foot. A woven wicker funnel was fastened to a 1-square-foot opening in the side. A 1-fathom branch line with an A.K. quick release snap spliced into the other end was fastened to one of the upper front corners of the pot. A blob of concrete hardened into the bottom or iron weights strapped to the bottom provided ballast. The total pot weight was around 6 pounds (Fig. 5a, 5b).

One hundred and fifty pots were obtained from Corn Island. These were initially divided into five strings of around 30 pots each, but gradual losses reduced this to four 30-pot strings during the latter part of cruise 71-2 and cruise 71-3; five, then four strings of 20 pots each were used during cruise 71-5. Strings of pots were usually set about 1 mile apart when they were the only exploratory gear. The pots were normally left in the water only 24 hours or less, depending on the operational schedule of the vessel.

Setting and Hauling.—Lobster pots were set in strings from the ship as

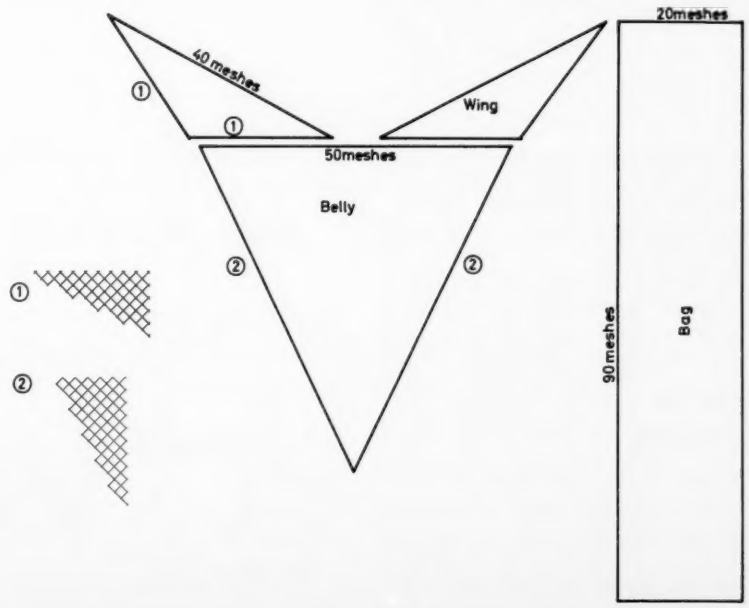

Figure 3.—Construction diagram of lobster try trawl.

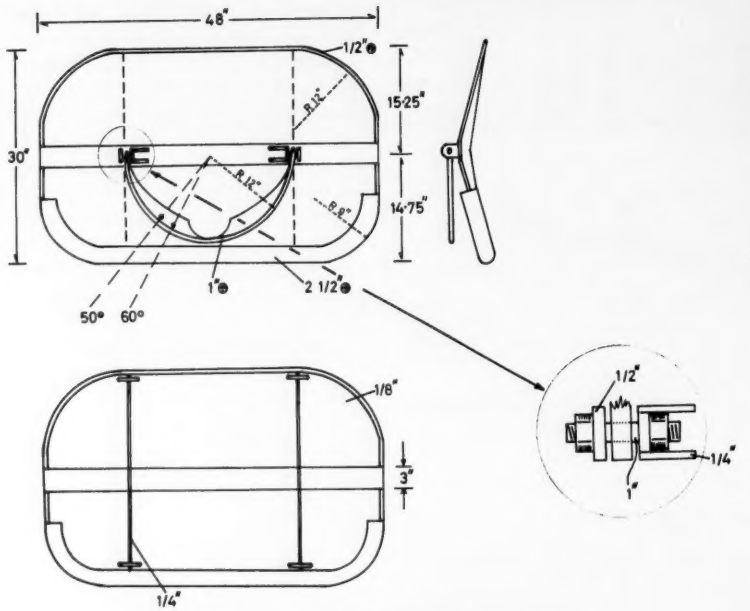

Figure 4.—Construction diagram of doors used with try trawl.

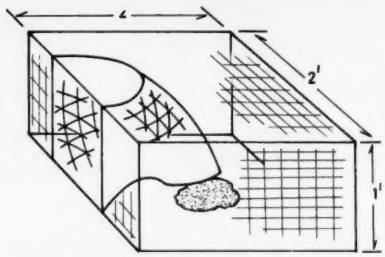

Figure 5a and 5b.—Nicaraguan wire mesh lobster pot.

she drifted downwind (Fig. 6). The pots were generally baited with both raw cowhide and frozen Spanish mackerel. A piece of hide about 6 inches × 3 inches was strung on one side of the funnel, and half a mackerel was strung on the other (Fig. 7). Usually the mackerel was replaced at each setting, but the hide lasted for periods of over a week. During the final cruise to the northern Leeward Banks, "robin" or round scad (*Decapterus* sp.) were exclusively used for pot bait.

During *Alcyon* cruise 71-1, the time required to set a string of pots was monitored on 38 occasions. Setting time varied from 8 to 15 min and averaged 11.8 min.

Pot strings were generally retrieved by running the ship slowly upwind. The average time required to haul a string of 30 pots was 17.5 min.

RESULTS

Try Trawling

It has already been stated that try trawling to locate lobster concentrations was dropped as part of the lobster survey technique early in cruise 71-2. The results of lobster trawling on Pedro Bank during cruise 71-1, as seen in Table 2 (see also Fig. 3) show that lobster catches by trawling were extremely light. Trawl drags were made in depths of 9 to 21 fathoms, but lobsters were caught only between 16 and 20 fathoms. Five drags were made on southeast Navidad Bank before trawling stopped. No lobsters were caught.

Lobster Pots

Pedro Bank

The data obtained from lobster pot catches taken on Pedro Bank are summarized in Figure 8 and Table 3. In Figure 8, there is some indication that catches were higher if pots were set in a narrow depth range rather than a wide one. It is of interest that most pot strings caught at least one lobster,

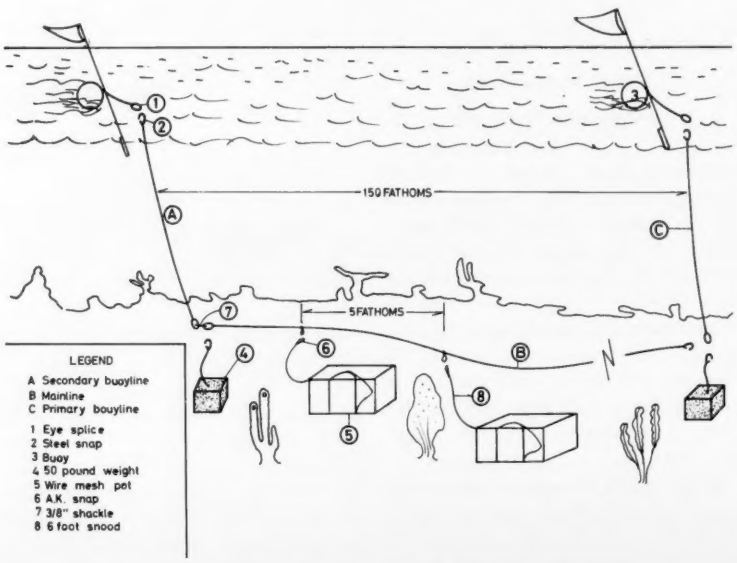

Figure 6.—Diagram showing method of rigging pot strings.

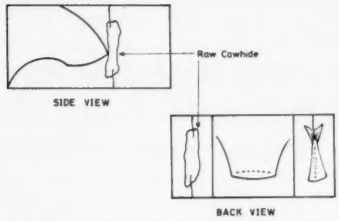

Figure 7.—Method of baiting lobster pots.

but no lobsters were taken from four strings set in grid H-13c. The highest catch rate observed from Pedro Bank was 0.45 lobster per pot, taken in grid H-12c on the western end of the bank. The catch rate of 0.14 lobster per pot from grid I-12a, located still on the western side of the bank but just south of H-12c, was equal to the overall average rate on Pedro Bank. About 800 pounds of assorted demersal fish, plus eight sand lobsters (*Passiabicus atarticus*) and 36 crabs, were also taken in the 2,078 pot lifts made.

Other banks

Lobster pot effort and catch data from all other banks explored are given in Table 4. The only significant catch came from the Morant Cays Bank, located southeast of Jamaica, where 10 strings totaling 268 pots caught 20 lobsters for a catch rate of 0.08 lobster per pot. No lobsters were caught on Albatross or Eight Mile Banks and insignificant catches were obtained from Mouchoir, Silver, and Navidad, and northern Leeward Islands Banks. About 1,100 pounds of assorted demersal fish, four sand lobsters, and 64 crabs were taken in the 1,055 pot sets.

Table 2.—Geographic distribution by 30 feet grid areas of try net drags on Pedro Bank (Cruise 71-1).

Area, Grid No.	H-12c	H-12d	H-13c	H-13d	I-12a	Total
No. of drags attempted	18	6	4	7	5	40
Depth range of drags, fathoms	14-20	9-18	11-15	19-21	12-17	9-21
No. of drags with lobster catch	2	0	0	3	1	6
No. of lobsters	3	0	0	3	1	7
Catch of lobsters per drag	0.17	0.00	0.00	0.43	0.20	0.175

Table 3.—Summary of lobster catch data from pot catches on Pedro Bank (Cruises 71-1 and 71-3).

Grid No.	H-12c	H-12d	H-13c	H-13d	I-12a	I-12b	I-13a	Total
No. of strings	8	4	4	20	4	8	25	73
Total pots recovered	224	111	110	592	112	226	703	2,078
Spiny lobsters caught	98	4	0	46	14	24	86	272
Lobsters per pot	0.44	0.04	—	0.08	0.13	0.11	0.12	0.13

Table 4.—Summary of lobster catch data from pot catches by area (Cruises 71-2, 71-3 & 71-5).

Area	Albatross	Morant Cays	Eight-Mile	Mouchoir	Silver	Navidad	N. Leeward Islands
No. of strings	5	10	2	8	13	10	34
No. of pots recovered	132	268	54	220	327	292	1,055
Depth range (fathoms)	18-20	13-25	18	8-13	10-16	13-17	9-150
Spiny lobsters caught	0	20	0	1	1	2	3

Fish Pots

The incidental catch results of fish pots set for comparative purposes in lobster fishing areas are given in Table 5. The fish pots caught only seven lobsters—all on Pedro Bank. The fish catch at lobster fishing depths was significant on Navidad Bank, where "Z" pots caught an average of 21 pounds per lift and on the northern Leewards' Banks, where "Z" pot hauls averaged 33 pounds per lift.

DISCUSSION AND SUMMARY

It was found during the project lobster explorations that the try trawl was not applicable in many areas, due to the rugged nature of the bottom and low catch rate. The wire mesh pot strings, however, proved to be adequate in determining the areas of greatest lobster abundance.

Various types of bait were used and though no specific bait preference experiments were conducted, it appeared that raw cowhide worked at least as well as fish bait and had the added advantage of extended life in the traps.

The availability of lobsters on the banks surveyed was shown to be, in general, low. The exception to this

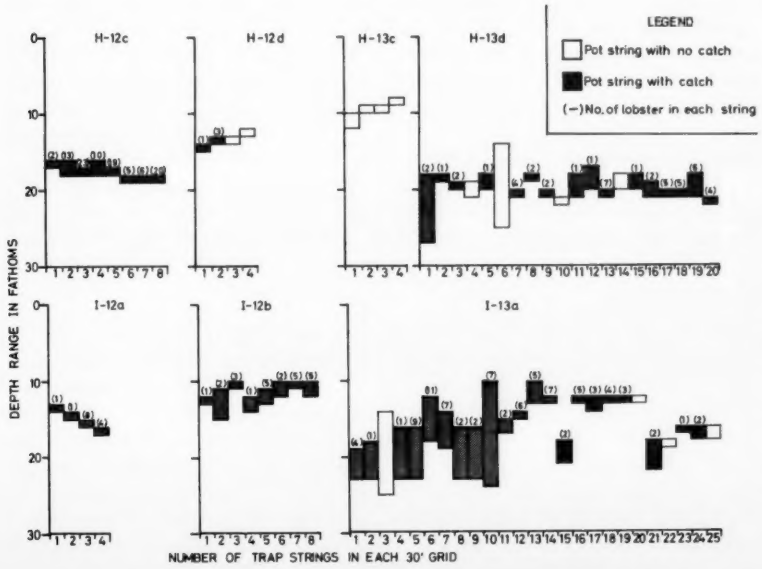

Figure 8.—Depth distribution by 30 foot grids of pot string sets on Pedro Bank.

Table 5.—Summary of fish pot catches on lobster grounds.

AREA	Pedro		Navidad	Silver	Mouchoir	N. Leeward Banks	
POT TYPE	Z	D	Z	Z	Z	Z	D
No. of pot hauls	6	5	6	5	2	26	6
Avg. soak (hr.)	157.0	157.0	21.7	18.7	14.5	16.4	16.4
Spiny lobsters (nos)	5	2	0	0	0	0	0
Sand lobsters (nos)	0	0	0	0	0	0	0
Crabs (nos)	0	0	0	0	0	0	0
Snappers (nos-lbs)	2-1.5	1-1.0	21-67.0	7-9.5	0-0.0	524-670.0	35-18.0
Groupers (nos-lbs)	0-0.0	0-0.0	6-51.0	2-17.0	2-13.0	20-128.0	1-13.0
Hinds (nos-lbs)	13-11.0	2-2.0	0-0.0	6-9.0	0-0.0	2-1.0	0-0.0
Grunts (nos-lbs)	41-23.0	9-10.0	21-8.0	2-1.5	0-0.0	0-0.0	0-0.0
Others (nos-lbs)	17-62.0	59-94.0	2-2.0	5-2.0	0-0.0	21-45.0	4-3.0

generalization was that certain areas of Pedro Bank produced relatively good catches, having commercial significance. Grid H-12c on the western end of the bank showed a pot catch rate which was considerably in excess of the average catch rate observed for similar wire mesh lobster pots during other lobster explorations in the Caribbean off Panama (Butler and Pease 1965). Although specific pot catch data are not available, a comparison of trawl net catch data between Pedro Bank and the continental shelf east of Honduras and Nicaragua would indicate that Pedro Bank possessed a much lower concentration of lobsters.

Even though a few lobsters were found on Morant Cays Bank, it is not likely that it could support much intensive lobster fishing because of its size.

The remarkable catch rates of lobsters taken incidentally in fish pots on Pedro Bank during earlier exploratory fishing efforts could not be duplicated with either lobster pots or fish pots during these investigations.

The higher lobster catch rates observed on the western side of Pedro Bank are indicative of a commercially available resource. Indeed, this fact was already known to some fishermen, as *Alcyon* observed a number of U.S. vessels fishing for lobsters along the northwestern edge of the bank during February and April of 1971.

It is unfortunate that other project exploratory efforts for lobsters both in the northern and southern portions of the project region were negative. There is ample evidence that lobsters are present in commercial quantities on the northern Leeward Islands Banks and in the Grenadine Islands. The total production of lobsters in Antigua (which would have been caught in Barbuda Bank) was estimated at 175,000 pounds in 1969 (Vidaeus 1971a) and in 1967, 65,000 pounds of lobsters, which were likely caught on Anguilla Bank, were exported from Nevis-Anguilla-St. Kitts (Vidaeus 1971b). In 1966 and 1967, the Windward and Leeward Islands were reported to have exported 31 and 35 metric tons of lobsters, respectively, into the United States (Windley 1968).

In the Grenadine Islands, a viable lobster fishery existed during 1969 and 1970. Don Crausbay used his 80-foot converted shrimp trawler, *American Lady*, and another smaller boat to fish 250 traps. These were normally raised twice per week to catch between 600 and 800 pounds of whole lobster. Their average individual weight was reported at 3.5 pounds, but the median was about 1.5 pounds. Basing his operation on Union Island, Crausbay fished his traps inside the area generally enclosed by Union, Maryean, and Little Martinique Islands in the west, and the edge of the island shelf in the east. He reported good catches at all fishing locations. Crausbay no longer fishes lobsters in this area, but the discontinuance was not due to a lack of resource.

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MFR PAPER 1087

Trap Fishing Explorations for Snapper and Related Species in the Caribbean and Adjacent Waters

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ABSTRACT—Pot or trap fishing is a recognized method for catching snapper and other demersal species from the inshore waters of most of the areas of the Caribbean. The Caribbean Fishery Development Project has extended its use to conduct explorations on the offshore banks of the Caribbean and the continental shelf off northeastern South America.

Explorations were concentrated on banks lying south, southeast, and southwest of Jamaica; north of Hispaniola; in the northern Leeward Islands; the Windward Islands; Barbados; and along the South American continental shelf from Venezeula to French Guiana.

The indigenous West Indian "Z" pot was compared primarily with the Australian "D" pot and to a lesser extent, with the "O" pot and a space saving nesting pot made to project design. Various sizes of pots, mesh sizes, baits, soaking periods, and fishing depths were compared.

"Z" pot catch rates averaged about 15 pounds each time a pot was lifted. This average was maintained on the Jamaican Banks, north of Hispaniola, and off Venezuela, Guyana, and Surinam. Higher catch rates of about 40 pounds per lift were obtained in the northern Leeward Islands and off French Guiana. The lowest averages of about 5-10 pounds per lift came from the Windward Islands.

The greatest proportion of the catch from the Jamaica Banks were grunts, triggerfish, squirrelfish, and porgies taken as a group. North of Hispaniola, snappers and groupers contributed about evenly to the catches. Nearly 75 percent of the catch in the northern Leeward Islands, the Windward Islands, and on the South American shelf was snappers.

The "Z" pot outfished "D" pots at a ratio of about 2:1 and the other pots by a much greater ratio. Larger pots and small mesh sizes displayed a greater catch rate. Atlantic herring, spanish mackerel, and West Indian "robin" (scad) baits all produced the same catch rate which exceeded that of flyingfish and sprats. The best overall catch rates were obtained from pots soaked for 1 day or less. The average size of snappers was greater with a larger sized mesh.

There is good potential for trap fishing in the Caribbean. Although ciguatera poisoning is a deterrent to catching demersal species north of Hispaniola and in the northern Leeward Islands, the silk snapper, which has constituted between 70 and 90 percent of the catch from 60-100 fathoms, has been found ciguatera free.

Fishing with traps or pots[1] has been traditional in the West Indies for many years. According to Munro, Reeson, and Gaut (1971) fish traps made of native materials have probably been in use for centuries, but the fish pot which is presently most widely used, namely that of a wire mesh enclosure strengthened with wooden sticks, has been in use for only the past 50 years. Although many styles of fish pot are in use in the West Indies, the "Z" shaped pot appears to be the most universal. This style of fish pot is used by inshore canoe fishermen from Jamaica to Trinidad and along the coasts of South America.

During Phase I of the Caribbean Fishery Development Project (November 1966 to August 1969), the highest proportion of the exploratory fishing effort had been placed on the resource of snappers and jacks in the project region (Interim Report No. 1, UNDP/FAO Caribbean Fishery Development Project, 1969). Most of this effort utilized handlines or mechanical reels, either hand-cranked or electric motor assisted, as the fishing method. While this method was found to be highly productive for the larger species, it was felt that traps would catch a greater size range of fish with a consequently greater number of species and also be more familiar to West Indian fishermen. Some experimental settings of fish traps during early exploratory handline cruises produced a significant positive result. Accordingly, during the project's second phase (September 1969-August 1971) a further intensive effort on the snapper-and-jack type of demersal resources was initiated using the fish pot. This effort was to complement handline exploratory efforts, both having taken place and proceeding concurrently. Very intensive coverage of certain areas would be included in an attempt to determine seasonal abundance.

EXTENT OF EXPLORATIONS

The project region extends from Central America eastward along the Greater Antillean Arc, turns south along the Lesser Antillean Arc to Trinidad, and then further southeastward to the border of French Guiana and Brazil. It also includes the Caribbean and that portion of the Atlantic lying east of the Lesser Antilles and north of the Guianas.

Regional Coverage

The areas explored with pots within the project region shown in Figure 1 are generally the same as those explored during handlining operations, since the results of handlining were used to help determine where empha-

[1] The terms trap and pot are used synonymously in this paper.

sis in pot fishing explorations would be placed. Specifically excluded from pot fishing explorations were the continental shelf areas east of Central America as this area is within the study area of the UNDP/FAO Central American Fishery Development Project.

Area Coverage

In the northern half of the project region explorations were conducted on banks south, southeast, and southwest of Jamaica, north of Hispaniola, and in the northern Leeward Islands. Coverage of these three areas was relatively intense and consisted of periodic cruises to determine seasonal abundance wherever possible. Thirteen cruises were expended here.

Once-only coverage (with some overlap) was given to the continental shelf from French Guiana west to Blanquilla Island north of Venezuela during three cruises. Grenada and St. Vincent in the Windward Islands along with Barbados were covered during portions of two cruises.

Jamaican banks

Pedro Bank, covering an area of nearly 2,400 square miles and lying about 60 miles southwest of Jamaica, is the largest of this group. Also included are the much smaller Albatross Bank, Salmon Bank, Decca Ridge, Mackerel Bank, Eight Mile Bank, Rosalind Bank, Serranilla Bank, and Alice Shoal, all lying southeast to southwest of Jamaica. Exploratory cruises to this area were made in February, April, July, and November of 1970.

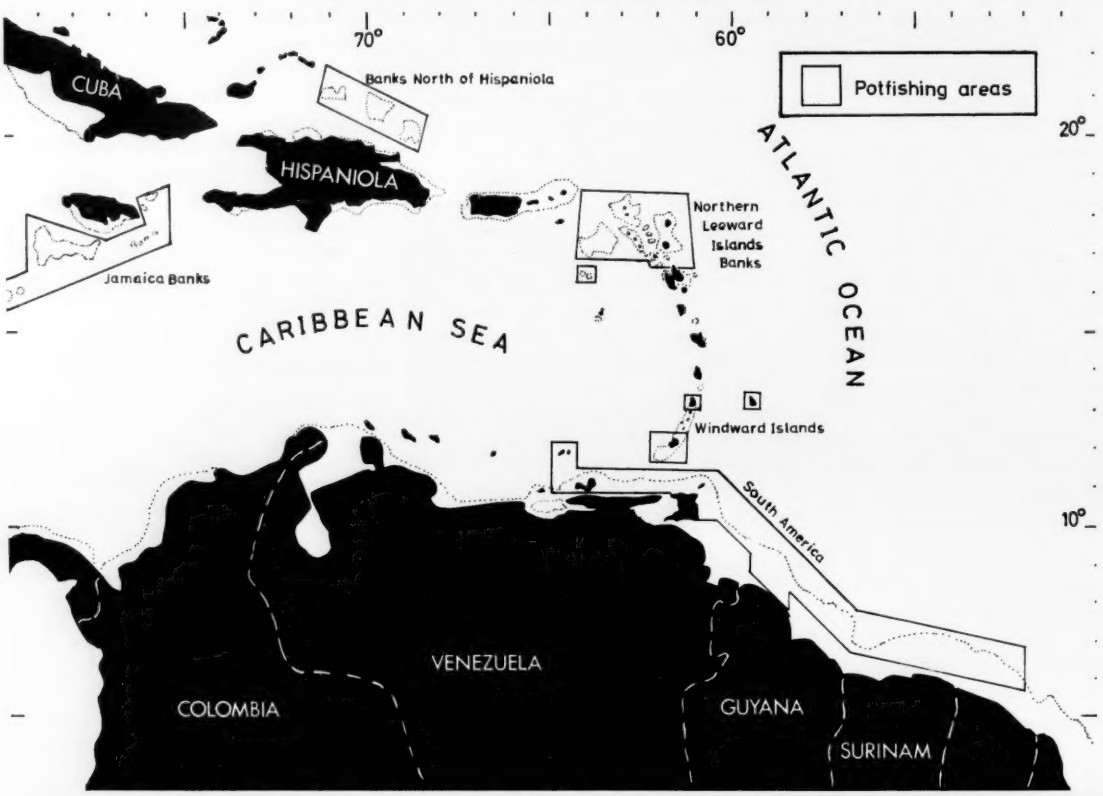
Banks north of Hispaniola

Navidad, Silver, and Mouchoir Banks lie 80 miles north of the island of Hispaniola. Though geologically a part of the Bahamas chain, these banks are the only sizeable offshore banks in the north central part of the project region. During Phase I of the project the Dominican Republic was a participant and handlining operations took place on the three banks. Even though this country was not a participant in Phase II, pot fishing explorations on those banks were conducted in January, May, and October 1970.

Northern Leeward Islands banks

There are three large bank areas in the northern Leeward Islands which are at the eastern end of the Greater Antilles and the northern end of the Lesser Antilles. Barbuda Bank, on which the islands of Barbuda and Antigua are located, is the farthest east. Anguilla Bank lying slightly to the northwest contains Anguilla, St. Martin, St. Barthélemy, and Dog Island. Moving to the southwest there is Saba Bank, which is completely submerged. Pot fishing explorations took place here in November 1969 and in March, June, September, and December of 1970. An experimental cruise to Saba Bank took place in April 1971.

Figure 1.—Project region showing areas of exploratory pot fishing.



South Leeward Islands, Gibbs Seamount, Windward Islands, Barbados

Because there are no extensive offshore banks below the northern Leeward Islands relatively little pot fishing effort was expended there. One exception was the Grenada shelf which received 3 days of direct exploratory coverage in January 1971. One set was made around St. Vincent in March 1971. A few pots were set around Barbados in April 1968 and one set in March 1971. Two exploratory sets were made on Gibbs Seamount (lat.16°32'N, long.63°56'W) in June 1971.

South America

The edge of the continental shelf off South America from Blanquilla Island, Venezuela east to Tobago then south and east to French Guiana was surveyed during three cruises in January, February, and March of 1971. Some pots were set on the shelf proper, but most effort was exactly at the shelf edge or on the slope adjacent to it.

EXPLORATORY FISHING EFFORT

Determination of Unit

Most of the exploratory fishing effort spent on pot fishing took place during the project's Phase II (1 September 1969-31 August 1971). Because the exploratory nature of the operations required the coverage of a rather large geographical area, the time spent at any one location during a cruise tended to be short. The basic unit of fishing effort therefore became the individual pot lift. Most data have been analyzed using this unit. There were, however, two principal and other lesser kinds of pot lifts based primarily on the elapsed time of pot soaking. The day lift was normally conducted from midmorning to midafternoon and averaged about 4.7 hours. The overnight lift was normally from late afternoon of one day to early morning of the next day and averaged about 15.4 hours. Occasionally, a pot would be left for a full day set, which averaged about 22 hours or longer.

A setting of pots consisted of from 6 to 16 pots in the same general location. Day sets usually contained fewer pots than overnight sets.

Amount

In all, 18 cruises were all or partially expended on pot fishing activities (Table 1). Most of the cruises consisted exclusively of pot fishing, but a few were combined with other work so that a total of over 300 sea days was expended for the purpose.

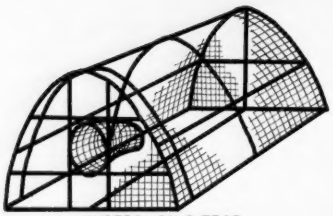
GEAR

The four styles of fish pot utilized during project pot fishing explorations are seen in Figure 2. While it was acknowledged that the "Z" pot was already the most familiar and universally employed trap in the West Indies, attempts were made to judge its effectiveness against other fish pots used in other parts of the world. Pot fishing for snappers has gained wide acceptance in Australia. Accordingly, a practicing snapper pot fisherman from Australia was made available to the project for a 5 month period. He introduced the "D" and "O" pots, which were fished comparatively with the "Z" pot, as was a nesting pot designed by the project to facilitate storing and handling aboard ship.

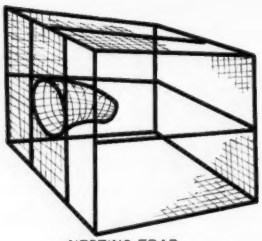
The "Z" pot is formed of hexagonal wire mesh (chicken wire) externally reinforced by a framework of hardwood sticks. Construction details of two styles of "Z" pots are given in Figure 3. Style A is preferred in the Lesser Antilles while both styles are used in Jamaica. The wire mesh is No. 14 or 16 Birmingham Wire Gauge (B.W.G.) galvanized, of 1½ inch or 2 inch opening. It is usually furnished in rolls 4 feet by 150 feet long. Depending on the length of trap desired (shown here at 9 feet) top and bottom sections are made up as in B or F. The height of the trap can be 2, 3, or 4 feet, depending on the preference of the builder, and the side walls cut accordingly. After bottom, top, and sides have been cut they are laced together with No. 20 B.W.G. binding wire. External strengthening is accomplished as shown in C or G by the use of hardwood sticks (mangroves preferred) wired to the outside of the mesh and wired together at junction points. The positions of vertical stick stiffeners are shown as black dots. When completed, the structure is completely rigid. Two entrance funnels (D and H) are fabricated of wire mesh and inserted at the apexes of the concave angles on each of the long sides of the trap (A and E). A door is cut

Table 1.—Exploratory cruises on which trapfishing was a major fishing effort.

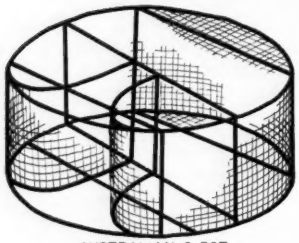
Vessel	Cruise	Month	Days pot fishing	Type of cruise	General area
Alcyon	67-6	June	6	Exploratory	Jamaica Banks
	67-8	Sept.	5	Exploratory	Banks N. of Hispaniola
	67-10	Nov.	6	Exploratory	Jamaica Banks
Fregata	68-3	Apr.	8	Exploratory	Barbados
Alcyon	69-11	Nov.	10	Exploratory	N. Leeward Is. Banks
	70-1	Jan.	19	Exploratory	Banks N. of Hispaniola
	70-2	Feb.	13	Exploratory	Jamaica Banks
	70-3	Mar.	26	Exploratory	N. Leeward Is. Banks
	70-4	Apr.	17	Exploratory	Jamaica Banks
	70-5	May	16	Exploratory	Banks N. of Hispaniola
	70-6	June	25	Exploratory	N. Leeward Is. Banks
	70-7	July	16	Exploratory	Jamaica Banks
Calamar	70-8	Sept.	17	Exploratory/ Experimental	N. Leeward Is. Banks
Alcyon	70-11	Oct.	7	Exploratory	Banks North of Hispaniola
	70-12	Nov.	9	Exploratory	Jamaica Banks
	70-13	Dec.	21	Exploratory	N. Leeward Is. Banks
Calamar	71-1	Jan.	24	Exploratory	N. Venezuelan Shelf-Grenada
	71-2	Feb.	18	Exploratory	Tobago-Trinidad-Guyana
	71-3	Mar.	4	Exploratory	St. Vincent-Barbados
	71-4	Mar.	17	Exploratory/ Experimental	French Guiana, Surinam, Guyana
	71-5	Apr.	10	Experimental	Saba Bank
	71-8	June	2	Exploratory	Gibbs Seamount



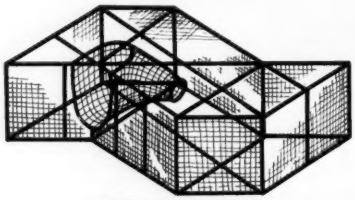
AUSTRALIAN D TRAP



NESTING TRAP



AUSTRALIAN O POT



WEST INDIAN Z TRAP

Figure 2.—Pot styles utilized during project exploratory operations.

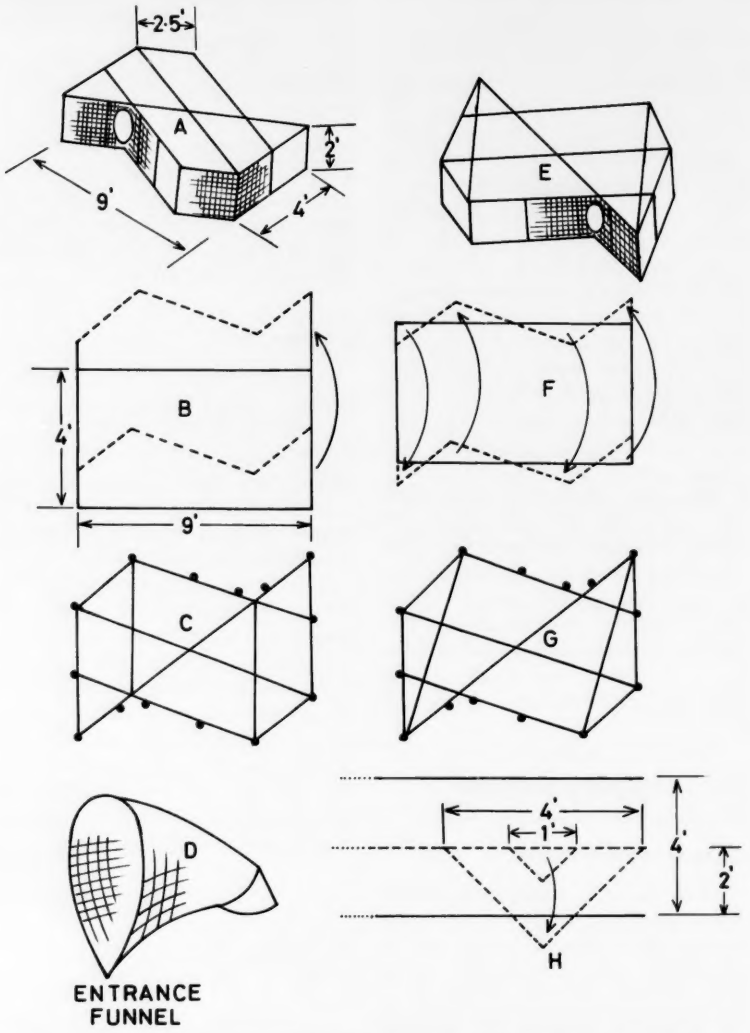


Figure 3.—Diagram showing the two methods most commonly used in constructing Z pots. Entrance funnel and side wall details also shown.

into the top to facilitate baiting and fish removal. A lifting bridle is fixed to the support sticks at one end.

The Australian "D" pot is shown in Figure 4. The frame base is constructed of 1 inch × 2 inch hardwood. Steel rods of ⅜ inch diameter, 10 feet long are hand bent into half circles and the ends passed through the frame and clinched on the underside. The entire structure is sheathed with wire mesh and stiffening sticks are wired along the upper portion. An oval funnel is made and inserted into one end of the trap and the lifting bridle fastened to the opposite end.

The "O" pot is shaped like a bass drum. The cylindrical steel rod frame is covered with mesh and one entrance funnel is fitted. The nesting type pot was devised by the project in order to increase the number of pots carried aboard a vessel, so as to increase the amount of fishing effort on a cruise. This pot was built in two sections for easy storage. Steel rod was used for framing. The first section was a truncated pyramid, 3 feet square on one end and 2 feet square on the other. The second section was a square frame, 3 feet on a side. Both sections were covered with wire mesh except for the 3-foot square end of the first section. The second section could be nested on top of others like it and stored until assembled for setting. To assemble, the entrance section was clipped to the open end of the pyramid section (funnel in). Both the "O" pots and the nesting pots were used experimentally during early cruises, but were abandoned as not worth the construction expense after their catching ability was found to be greatly inferior to "Z" and "D" pots.

BAIT

During the early phases of pot fishing, all pots were baited with cut, frozen Atlantic herring (*Clupea ha-*

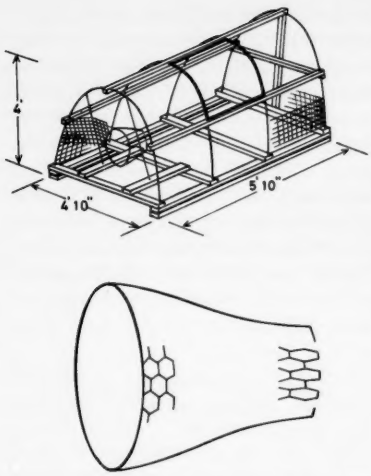


Figure 4.—Diagram illustrating "D" pot and funnel construction.

rengus harengus) imported from eastern Canada. Early in 1970, it was no longer possible to obtain herring, so frozen Spanish mackerel (*Scomberomorus maculatus*) were imported from Florida. In May of 1970, a glut of West Indian "robins" (round scad—*Decapterus punctatus*) caught in the Grenadines occurred in the markets in St. Vincent. This allowed the project to purchase a supply and for the first time locally caught pot bait was used. Robins were used together with Spanish mackerel until March of 1971, when further supplies of robins enabled us to discontinue the use of imported bait. At various times, Barbados-caught fourwing flyingfish (*Hirundicthys affinis*), sprats (*Harengula* sp.), sharks, and some of the food fish catch were tested for suitability as pot bait.

FISHING METHOD

Beginning in November 1969 (*Alcyon* cruise 69-11), a full-scale program was initiated to assess the demersal fish resources obtainable by pots in the relatively productive areas found during earlier handline and reel exploratory fishing. This was continued through June 1971. Gear experimentation using different types of pots was included as well. All pots were rigged with a 100-fathom polypropylene lift rope (1 inch circumference), one end of which was tied to the lifting bridle on the pot and the other end to a large inflatable highly visible float painted with a distinguishable identification number. Another small float was attached to a position on the rope such that the length between this float and the pot was approximately the same as the depth of water in which the pot was to be set. The remaining rope between the two floats was shortened to a length of 5 to 10 fathoms by coiling up the excess. Each pot was baited with 5 pounds of cut bait strung on a wire or wires and hung from the top of the pot, just inside the inner end of the entrance funnel. "D" pots having one funnel entrance were carefully set running against the current in order to maximize the chance that the funnel entrance would open down current when the pot came to rest.

Typically, the pots were set along the edge or slope of a shelf at intervals of about 100 to 150 yards. While the pots were being prepared for setting, close examination of the bottom topography was carried out by echo sounder to find a proper location for setting. On steep slopes the pots were set close to, but inside of, the drop-off edge, but if the slope was reasonably gradual they were set on the slope down to 100 fathoms. Shallow water settings of 25-35 fathoms on the shelf were chiefly made around ridges, bottom risings, or outcroppings as distinguished by the echo sounder.

The pots were left in the water for 3 to 5 hours for a daytime set, or overnight (before sunset to after sunrise) for a night set. They were retrieved one by one using a hydraulic pot hauler[2] suspended from the forward trawl gallows. Catches were recorded for each pot with details of time set and lifted, depth, number and weight of each species, mesh size, type of pot, etc.

RESULTS

Species Composition

The species composition of the catch from all pot fishing is given in Table 2. It shows generally that the proportions of the various species and family groups changed measurably between the different areas explored. On the Jamaica Banks, as shown in Figure 5, the largest portion of the catch by weight in all months when fishing took place was made up of the "lesser reef fishes." Groupers formed the next higher proportion except during June. Groupers and snappers alternately formed the highest proportion of the catch from the banks north of Hispaniola, as seen in Figure 6. Snappers form an overwhelming proportion of the weight of fish taken on the banks in the northern Leeward Islands (Fig. 7) and silk snappers (*Lutjanus vivanus*) are the most abundant species caught. North of central Venezuela, in the Windward Islands, from the banks north of Hispaniola, and the Jamaica Banks, the blackfin snapper (*L. bucanella*) predominates (Fig. 8). Indeed, this species was the only snapper represented in the catch of all areas explored. Caribbean red snapper (*L. purpureus*) dominates the catches off the continental shelf from Trinidad south and east to French Guiana. Groupers formed a significant but generally secondary proportion of the catches from all areas. Jacks (Carangidae) did not form a large proportion of the catch from any area.

Catch Rate

The catch rates observed for various fish pot types and areas are given as total pounds of fish per pot lift. Pot lifts may be from daytime sets, overnight sets, or, on a few occasions, a full 24 hour day or longer. Catch rate data are presented as a/b-c; a, the number of pot lifts; b, the average number of fish caught per lift; and c, the average weight of the catch per lift. Since all fish can be utilized in the West Indies, the significant figure becomes the average number of pounds per pot lift. This can be considered an indication of what a fisherman might expect to catch, on an average, every time he sets and lifts his pots under the same conditions of depth, bait, pot size and configuration, and general fishing area, as those used by the project.

Jamaica banks

The results of all project exploratory pot fishing on the banks near Jamaica are given in Table 3. Results are given for the various pot styles and mesh

[2] Marco J.0105 Crab Block. Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Table 2.—Catch composition of trap fishing by cruise. (Numbers of fish - weight in pounds.)

Cruise number	General location	Blackfin snapper (*L. buccanella*)		Silk snapper (*L. vivanus*)		Red snapper[1] (*L. purpureus*)		Yellowtail snapper (*O. chrysurus*)		Vermillion snapper & Wenchman[2]		All snapper[3] (Lutjanidae)		Hinds & Coneys		All grouper[3] (Serranidae)		All jacks (Carangidae)		Lesser reef fishes[4]		Other		Total	
A67-6	Jamaica banks	7-	4	0-	0	0-	0	91-	130	0-	0	105-	138	0-	0	9-	93	0-	0	160-	197	3-	18	277-	446
A67-8	Banks N. of Hispaniola	-	129	-	0	-	0	-	8	-	0	-	137	-	0	-	239	-	33	-	44	-	44	-	497
A67-10	Jamaica banks	24-	26	0-	0	0-	0	54-	94	0-	0	98-	151	150-	156	182-	526	22-	33	659-	647	154-	138	1,115-	1,495
F68-3	Barbados	26-	25	117-	154	0-	0	0-	0	0-	0	143-	179	0-	0	0-	0	63-	229	0-	0	8-	4	214-	412
A69-11	N. Leeward Is. banks	126-	181	618-	695	1-	2	18-	32	202-	157	1,106-	1,086	56-	83	95-	469	10-	69	288-	147	12-	53	1,511-	1,824
A70-1	Banks N. of Hispaniola	136-	358	0-	0	0-	0	30-	67	0-	0	178-	455	195-	283	334-	1,592	1-	10	437-	464	14-	299	964-	2,820
A70-2	Jamaica banks	93-	119	0-	0	0-	0	13-	41	2-	1	135-	257	182-	186	244-	775	9-	36	1,022-	993	20-	48	1,430-	2,109
A70-3	N. Leeward Is. banks	958-	1,478	2,982-	3,010	7-	33	81-	121	531-	355	4,599-	5,037	20-	29	115-	1,190	11-	102	73-	117	12-	45	4,810-	6,491
A70-4	Jamaica banks	475-	703	70-	119	0-	0	72-	150	0-	0	624-	987	490-	641	525-	1,097	0-	0	1,553-	1,475	228-	250	2,930-	3,809
A70-5	Banks N. of Hispaniola	725-	1,688	0-	0	0-	0	4-	6	0-	0	730-	1,700	75-	76	132-	603	0-	0	130-	115	7-	32	999-	2,450
A70-6	N. Leeward Is. banks	548-	1,007	2,204-	2,100	1-	3	15-	25	233-	123	3,013-	3,273	15-	21	105-	816	4-	33	64-	26	16-	46	3,202-	4,194
A70-7	Jamaica banks	378-	393	0-	0	0-	0	0-	0	0-	0	412-	504	714-	685	799-	1,459	72-	159	4,017-	2,588	176-	182	5,476-	4,892
C70-8	N. Leeward Is. banks	1,271-	1,845	6,536-	6,999	0-	0	45-	67	957-	626	8,815-	9,624	28-	40	170-	1,783	250-	1,062	86-	142	31-	23	9,352-	12,634
A71-11	Banks N. of Hispaniola	407-	756	0-	0	0-	0	0-	0	0-	0	467-	868	156-	171	288-	721	0-	0	57-	69	18-	17	770-	1,675
A70-12	Jamaica banks	-	116	-	0	-	16	-	77	0-	0	-	210	-	180	-	261	-	53	-	662	-	55	-	1,241
A70-13	N. Leeward Is. banks	1,077-	1,235	2,888-	3,703	0-	0	127-	166	185-	146	4,279-	5,253	52-	55	103-	442	78-	366	133-	86	133-	126	4,726-	6,273
C71-1	Venezuelan Shelf	306-	645	7-	18	28-	139	8-	27	240-	244	598-	1,107	114-	182	245-	656	83-	104	1,193-	1,179	190-	393	2,309-	2,377
C71-2	Trinidad-Guyana Shelf	6-	22	7-	21	353-	901	0-	0	854-	252	1,232-	1,239	0-	0	69-	568	4-	11	1,245-	484	57-	104	2,607-	2,406
C71-3	St. Vincent-Barbados	111-	151	42-	55	2-	15	0-	0	2-	3	158-	232	2-	4	2-	4	15-	26	20-	9	1-	3	196-	274
C71-4	French Guiana-Surinam-Guyana	20-	75	0-	0	2,453-	4,804	0-	0	1,409-	592	3,883-	5,471	0-	0	93-	1,018	3-	28	158-	65	3-	13	4,139-	6,595
C71-6	Saba Bank	97-	164	2,856-	2,843	0-	0	0-	0	57-	37	3,010-	3,044	0-	0	11-	95	36-	220	2-	8	8-	36	3,067-	3,403
C71-8	Gibbs Seamount	3-	12	0-	0	0-	0	0-	0	0-	0	5-	19	3-	10	23-	174	20-	75	95-	196	3-	10	146-	474
	Totals (weight)		-11,132		-19,717		-5,913		-1,011		-2,536		-40,971		-2,802		-14,581		-2,649		-9,713		-1,939		-88,791

[1]Identification according to Rivas (1966).
[2]Vermillion snapper (*Rhomboplites aurorubens*); Wenchman (*Pristipomoides aquilonaris*).
[3]Includes fish of other snapper species in addition to those specifically identified.
[4]Grunts (Pomadasyidae); Triggerfish (Balistidae); Squirrelfish (Holocentridae); Porgies (Sparidae).

sizes used and the banks fished. Catch rates for "Z" pots having 1¼-inch mesh set on Pedro Bank are available from cruises 67-6, 67-10, 70-4, 70-7, and 70-12, covering the months of April, June, July, and November. In those instances where different pot styles were set randomly at the same time, the "Z" pot displays a consistently higher catch rate than any other. The "D" pot outfished both the nesting pot and the "O" pot by a wide margin. Assuming that the approximate 2.3:1 ratio of 1¼-inch Z pot catch rate to 2 inch "D" pot catch rate which was observed during cruises 70-4 and 70-7 would have been obtained during cruise 70-2, we can calculate an overnight "Z" pot catch rate of about 56 pounds per set for "Z" pots on Pedro Bank in February.

Banks north of Hispaniola

The results of exploratory trap fishing effort on the banks located north of Hispaniola are given in Table 4. Here again, where comparable data are available, the "Z" pot outfishes the "D" pot, this time at the ratio of about 1.5:1. During cruise 70-1 in January 1970, catch rates appeared to be highest on Silver Bank, but in May the catch rates were highest on Navidad Bank. Mouchoir Bank showed lower catch rates. Where comparable data were gathered, daytime sets appeared more productive than overnight ones.

Northern Leeward Islands banks

This area received the most concentrated exploratory pot fishing effort of any in the project region. This came about because initial efforts indicated higher catch rates here than in the previous two areas. The results of this effort are given in Table 5. Again, where comparable data exist, the "Z" pot was seen to outfish the "D" pot. Here, it was by about 2 to 1 and other pots by an even higher ratio. Due to the topography, it was possible to fish deeper off the edges of these banks than on the banks off Jamaica or north of Hispaniola. Where good comparable data are available, as with "D" pots on Barbuda Bank during cruise 70-3, with "D" pots on Saba Bank and both "D" and "Z" pots on Barbuda Bank during cruise 70-6, it can be seen that fishing on the slope

of the bank in deeper water, where the angle of slope allows, invites a higher catch rate than fishing on the bank edge.

Catch rates were highest most often on Saba Bank. Barbuda Bank was the next most productive, while Anguilla Bank was the least productive. Speaking generally, overnight catch rates were higher than daytime catch rates, although there are exceptions. Catch rates on these banks are generally higher than off Jamaica and north of Hispaniola.

Gibbs Seamount, Windward Islands, and Barbados

There was no specific pot fishing exploration conducted in the southern Leewards. It is assumed, however, that pot fishing observed in the Windward Islands would be comparable to that of the southern Leewards. A limited amount of pot fishing exploration was conducted in the Windward Islands and Barbados during three cruises. Results are given in Table 6. Catch rates observed were significantly less than from the three areas in the northern half of the project region. Again, where comparable data exist, overnight catches exceed daytime ones. The daytime catch rate at Gibbs Seamount is encouraging.

South American continental shelf

The results of pot fishing explorations conducted on the continental

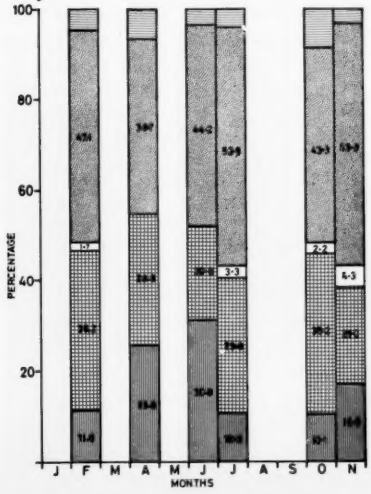


Figure 5.—Proportional catch composition by weight—Jamaica banks.

Table 3.—Observed trap fishing catch rates on the Jamaican banks.
(No. of traps lifted/aver. no. of fish per lift - aver. weight of fish catch per lift)

Vessel and Cruise Month Trap type-(mesh size)	*Alcyon* 67-6 June "Z" - (1¼")	*Alcyon* 67-10 November "Z" - (1¼")	*Alcyon* 70-2 February "D" - (2")	Nesting - (2")	*Alcyon* 70-4 April "Z" - (1¼")	"D" - (2")	"O" - (2")	*Alcyon* 70-7 July "Z" - (1¼")	"D" - (2")	*Alcyon* 70-12 November "Z" - (1¼")	"D" - (2")
Location											
Pedro Bank											
Day	6/-64.7	—	4/12.3-29.0	—							
Overnight	7/-54.3	158/19.4-25.7	25/28.4-24.4		14/47.2-40.0	132/11.3-16.5	47/3.3-5.9	150/26.2-16.2	12/5.7-7.0	42/-20.4	11/ -2.1
Salmon Bank											
Day											
Overnight			12/16.2-28.3	1/0 - 0							
Albatross Bank											
Day			8/8.1 -29.5	1/24.0-54.5							
Overnight			16/15.2-32.6	2/17.0-60.0							
Decca Ridge											
Day											
Overnight			8/7.8 - 8.3	1/7.0 -15.0							
Mackerel Bank											
Day											
Overnight			7/6.7 - 2.4	1/8.0 - 2.0							
Eight Mile Bank											
Day								76/16.4-22.4	22/5.0-11.2		
Overnight											
Rosalind Bank											
Day										1/88-68.5	
Overnight											
Seranilla Bank											
Day										6/31.2-41.9	
Overnight											
Alice Shoal											
Day										6/4.2-5.2	5/1.2-3.7
Overnight										55/ -22.0	16/ -2.6
Totals	13/-59.1	58/19.4-25.7	80/17.1-23.8	6/12.2-32.0	14/47.2-40.0	132/11.3-16.5	47/3.3-5.4	226/22.9-18.3	34/5.3-9.7		

[1]Includes sets of 1-5 days duration.

shelf of South America (and Trinidad) are given in Table 7. These grounds were not surveyed on a seasonal basis as were those in the northern half of the project region. Catch rates ranged from relatively poor off the northern Venezuela and Trinidad coasts, to progressively better working south and east from Trinidad to Guyana, Surinam, and French Guiana. Catch rates from French Guiana and Surinam are as high as those observed in the northern Leeward Islands. Here again, where good comparable data are available, "Z" pots catch at twice as high a rate as "D" pots and overnight catch rates exceed daytime rates.

Factors Affecting Catch Rate and Species Composition

Comparison of bait effectiveness

During *Calamar* cruise 70-8 a test comparing the attractiveness of frozen West Indian robin bait to that of frozen imported Spanish mackerel was carried out. Twenty comparative multipot settings were made using "Z" pots of equal size and evenly divided mesh sizes. Efforts were made to keep each pot at the same depth level during each setting. The results are presented as the number of pots lifted and the average catch per pot in pounds. (The uneven number of pots set is due to pot loss.)

	Robin	Mackerel
1¼ inch mesh	73/46.0	73/44.6
2 inch mesh	69/41.7	78/40.1

Although the slight reduction in catch per pot lift between robin-baited pots and mackerel pots was consistent with both mesh sizes, it was not of sufficient magnitude to be significant and the two baits were concluded to be equally attractive.

On *Calamar* cruise 70-4 the effectiveness of flyingfish and sprat herring pot bait was tested against robin bait. A total of 29 "Z" and "D" pots baited with robins is compared with 14 "Z" pots baited with flyingfish and 11 "Z" and "D" pots baited with sprat herring. The number of pots hauled and the average catch per pot are shown below:

Pot	Robin	Flyingfish	Sprat herring
"Z"	25/39.4	8/21.1	6/13.3
"D"	4/11.0	6/9.8	5/3.8

Table 4.—Observed trap fishing catch rates on the banks north of Hispaniola. (No. of traps lifted/aver. no. of fish per lift - aver. weight of fish catch per lift)

Vessel and Cruise Month	*Alcyon* 67-8 September	*Alcyon* 70-1 January		*Alcyon* 70-5 May		*Alcyon* 70-11 October
Trap type - (mesh size)	"Z" - (1¼")[1]	"Z" - (1¼")	"D" - (2")	"Z" - (1¼")	"D" - (2")	"Z" - (1¼")
Location						
Navidad Bank						
Day			6/1.8-5.3			
Overnight	10/ - 18.4	2/8.5-30.5	20/4.0-22.6	42/9.5-22.1	85/6.2-15.7	79/8.6-18.3
Silver Bank						
Day		3/13.3-46.7	10/7.3-29.3			
Overnight	11/ - 30.8	12/17.9-36.8	31/7.9-17.2	6/6.3-13.3	20/1.2-3.8	6/15.0-34.9
Mouchoir Bank						
Day		3/2.7-12.7	20/3.6-14.8			
Overnight		5/7.0-16.6	20/8.0-21.9			
Totals	21/ - 24.9	25/12.6-30.6	107/6.0-19.1	48/9.1-21.0	105/6.2-13.4	85/9.1-19.7

[1]Sets of 1-5 days duration.

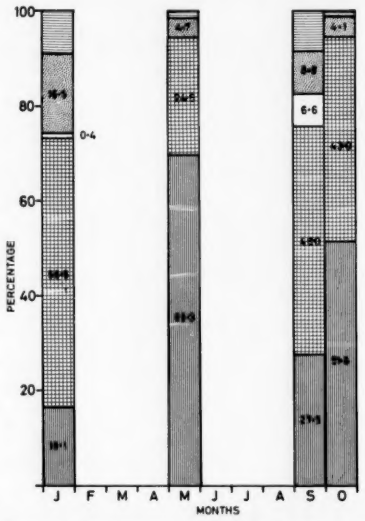


Figure 6.—Proportional catch composition by weight—banks north of Hispaniola.

Robins proved to be the most effective of three local West Indian species tested. Shark and pot-caught food fish were tested and were found to be poor pot bait.

The amount of bait placed in each pot was determined generally by experience. When pot fishing explorations began in earnest during Phase II, the Australian consultant fisherman advocated the use of much bait—up to 25 pounds per trap set. Since bait is expensive, the practice could not be followed for a long time. From March 1970 on, only 5 pounds per pot or two wires was the standard baiting, with no visible effect on catch rate.

W. High of the National Marine Fisheries Service, Northwest Fisheries Center (personal communication—K. Kawaguchi), reported on underwater observation of shallow-set pots during the Tektite II diving operations near St. John, U.S. Virgin Islands. There unbaited pots appeared to catch fish as well as baited pots. Likewise, Munro et al. (1971) actually found unbaited traps to be 15 percent more effective in catching fishes, but a heavier weight of fish was taken from baited traps. They also report the use of fruit and vegetable baits and other fish attractants like broken crockery. This latter may also aid fishermen in relocating traps in shallow water. On several occasions this project has compared the catch of baited and unbaited pots in deeper waters. On all occasions the unbaited pots caught little or nothing, while the baited pots continued to produce at their usual levels. It would appear that bait is a much greater and more necessary attraction in deep water than in shallow.

Fishing depth

Unlike handline fishing, a setting of pots usually required a relatively

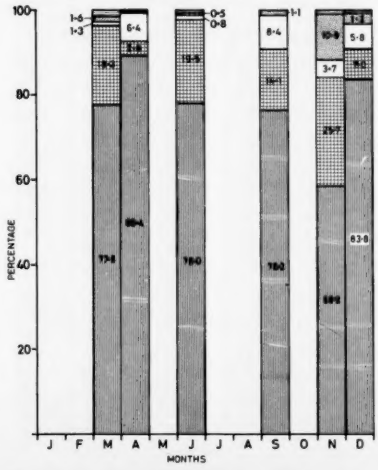


Figure 7.—Proportional catch composition by weight—northern Leeward Islands banks.

Figure 8.—Proportional catch composition by weight—South American shelf—Windward Islands.

gentle slope at the desired 50-100 fathom depth to be most successful. This was discovered by experience when pots set on too steep a slope were tumbled down it by current action and, depending on ballast weighting, either pulled their marker buoys under or floated away. It was possible to anchor the pots, but this led to increased strain on the pots and warps during hauling, which caused pot breakage and losses. Where the required gentle slope did not exist, it became standard practice to set the pots as close to the drop off of the bank or continental shelf edge as possible. This was often at 20-30 fathoms. Slope angle then became the determining factor in what depth the pots were set and how successfully they caught fish. Pot losses during explorations ran between 10 and 20 percent per trip and were usually the result of tumbling down slope.

Pot size

On *Calamar* cruise 71-4 a combination of many pot types of different dimensions and mesh sizes was utilized. A comparison of the effectiveness of "Z" pots by size was made. Forty lifts of 1¼-inch mesh Jamaican-built pots, measuring 9 × 4 × 2 feet were compared with 40 lifts of 2-inch mesh project-designed "Z" pots built in Barbados which measured 10 × 4 × 3 feet. Even with the reduction of overall catch rate expected from 2-inch mesh over 1¼-inch mesh, the

Table 5.—Observed trap fishing catch rates on the northern Leeward Islands banks. (No. of traps lifted/aver. no. of fish per lift - aver. weight of fish catch per lift.)

Vessel and Cruise Month Trap type - (mesh size)	*Alcyon* 69-11 November "Z" - (1¼")	"D" - (2")	"O" - (2")	*Alcyon* 70-3 March "Z" - (1¼")	"D" - (2")	Nesting - (2")	*Alcyon* 70-6 June "Z" - (1¼")	"D" - (2")	*Calamar* 70-8 September "D" - (1¼")	"Z" - (2")	*Alcyon* 70-13 December "Z" - (1¼")	"D" - (1¼")	*Calamar* 71-6 April "Z" - (1¼")	"D" - (1¼")
Location														
Saba Bank														
Bank edge														
Day							3/16.0-14.4							
Overnight							7/3.6-2.9							
Bank slope														
Day	5/48.1-34.1	7/17.4-17.7	9/10.0-19.9					23/2.3-4.4						
Overnight				14/59.0-52.1	26/10.7-16.1	8/9.5-9.6	29/16.6-13.5		25/2.7-4.4	41/31.5-32.6	40/16.3-33.6	43/24.9-33.8		
Anguilla Bank	4/51.0-49.0	6/51.7-69.0	6/3.8-3.6	25/56.4-55.6	38/20.3-34.0	12/11.3-15.1	44/18.3-14.5		41/5.2-6.8	48/56.1-54.7	50/29.9-37.9	38/28.6-37.2	[2]53/49.3-55.6	[2]14/33.4-33.9
Bank edge														
Day												37/26.8-31.2		
Overnight	2/3.0-10.3	10/6.6-14.8	8/5.5-12.0											
Bank slope														
Day							7/3.3-13.0		7/0.3-2.0					
Overnight				12/13.1-35.1	24/3.8-18.0	6/2.3-10.3	21/8.8-20.6		17/3.6-9.5	7/15.6-33.6	8/13.3-35.0			
Barbuda Bank														
Bank edge														
Day				5/28.0-37.9	24/8.8-18.8	6/4.3-9.6	11/7.1-7.6		11/0.8-2.2					
Overnight														
Bank slope				5/65.4-47.0	14/1.1-4.6	2/0.0-0.0	34/4.3-9.4		36/2.2-6.9	19/14.2-29.1	19/26.3-63.7	12/30.2-45.9		
Day	4/27.3-15.1	12/9.9-12.9	11/17.4-21.7	11/15.8-18.7	17/11.6-30.6	4/1.0-2.8	31/16.4-15.7		30/6.7-15.5	31/49.1-61.3	32/23.2-38.8	35/24.2-33.1		
Overnight	15/37.3-29.9	35/17.6-24.1	34/10.3-15.8	72/41.0-42.0	143/10.9-22.2	38/6.8-10.3	187/12.3-13.4		190/3.6-7.4	146/40.3-45.5	149/23.4-40.1	165/26.4-34.7	53/49.3-55.6	14/33.4-33.9
Totals														

[1]Nesting pot.
[2]Includes sets of 1-5 days duration.

Table 6.—Observed trap fishing catch rates on Gibbs Seamount and the Windward Islands. (No. of traps lifted/aver. no. of fish per lift - aver. weight of fish catch per lift.)

Vessel and Cruise Month Trap type - (mesh size)	*Fregata* 68-3 April "Z" - (1¼")[1]	*Calamar* 71-1 January "Z" - (1¼")	*Calamar* 71-3 March "Z" - (1¼")	*Calamar* 71-8 June "Z" - (1¼")
Location				
Gibbs Seamount				
Day				6/20.3-65.3
Overnight				6/4.0 -13.6
St. Vincent				
Day				
Overnight			11/11.1-15.0	
Barbados				
Day				
Overnight	16/13.4-25.7		11/6.1 - 8.1	
Grenada				
Day		48/6.5-9.5		
Overnight		48/8.5-15.4		
Totals	16/13.4-25.7	96/7.5-17.5	22/8.6 -11.5	12/12.2-39.5

[1]Includes sets of 1-4 days duration.

Table 7.—Observed trap fishing catch rates around Trinidad and on the South American continental shelf. (No. of traps lifted/aver. no of fish per lift - aver. weight of fish catch per lift.)

Vessel and Cruise Month Trap type - (mesh size)	*Calamar* 71-1 January "Z" - (1¼")	*Calamar* 71-2 February "Z" - (1¼")	 "D" - (2")	*Calamar* 71-4 April "Z" - (1¼")	 "D" - (1¼")
Location					
Venezuela					
North coast					
Day					
Overnight	80/3.0- 6.5				
Isla Blanquilla					
Day	7/0.0- 0.0				
Overnight	48/20.9-17.3				
Islas Testigos					
Day					
Overnight	32/1.0- 2.1				
Trinidad					
North edge					
Day					
Overnight	48/5.6-11.1				
East Edge					
Day		72/2.0-1.9	22/0.5-2.6		
Overnight		56/27.8-11.6	18/0.3-0.2		
Venezuela					
East Edge					
Day				19/7.1-24.5	4/2.2-16.2
Overnight		19/7.4-8.4	5/1.2-3.2	29/12.1-20.3	18/22.7-18.6
Guyana shelf					
Day		28/10.9-5.4	3/0.0-0.0		
Overnight		11/11.9-41.6	4/9.1-14.0		
Guyana edge					
Day		14/4.1-10.1	2/0.5-3.5	10/3.3-9.3	3/21.6-9.3
Overnight		38/11.7-13.0	3/1.3-9.3	8/41.0-21.9	
Surinam edge					
Day				10/1.5-14.6	3/6.0-2.0
Overnight				10/9.3-49.5	3/5.3-8.0
French Guiana edge					
Day				38/21.6-33.0	11/17.7-15.9
Overnight				38/16.9-64.3	9/30.4-32.3
Totals	215/7.2-9.0	235/10.8-9.2	57/1.2-2.9	162/19.3-34.9	51/20.8-18.1

large pots, average catch of 30.1 pounds per lift significantly exceeded the 18.7 pounds per lift figure of the small pots having only 1¼-inch mesh. It thus appears that pot size is of greater significance than mesh size in determining its effectiveness.

The mechanism behind such a relationship is not clear except that during *Calamar* cruise 71-6, when only "Z" pots of 1¼-inch mesh were fished, there was a positive correlation (not significant) between pot height and catch rate. When the pot catch rate was compared with pot length, pot width, and pot volume the correlation was not evident.

Mesh size

Catch rate variation.—During *Calamar* cruise 70-8 comparative tests on the effects of mesh size were conducted. All pots used were of equal dimensions, baited with either Spanish mackerel or West Indian robins. Each test consisted of about the same number of 2-inch mesh and 1¼-inch mesh pots, usually eight large and eight small, placed at about the same depth. Results are given as the total number of pot lifts and the average weight of fish caught per lift. A comparison of catch rates between day and overnight sets follows:

	2 inch mesh	1¼ inch mesh
Day	59/44.2	60/31.6
Overnight	88/33.7	86/54.9
Combined	147/40.9	146/45.3

The catch rate of 2-inch mesh pots is considerably better during the day sets, while during overnight sets the small mesh pots outperformed the large mesh ones.

Although "Z" pots having 1¼-inch mesh and "D" pots having 2-inch mesh were fished comparatively during many cruises, it was not until *Calamar* cruise 71-4 that a direct comparison between "D" and "Z" pots of the same 1¼-inch mesh was made. During 14 multipot settings which included from 2 to 6 pots of each type, a total of 47 "D"-pot lifts produced an average catch of 19.6 pounds per lift, while 58 "Z"-pot lifts produced 41.4 pounds per lift.

Fish size and species variations.—Because of the general size differences of the various species and families included in the fish pot catches of the region, the species composition of the catch is affected by mesh size. During *Calamar* cruise 70-8, a comparison was made of the proportions by weight of snappers, groupers, jacks, and others by mesh size in the "Z" pot catches on Saba Bank. This location was selected because the general evenness of slope allowed all pots to be set at approximately the same depth. Proportions of family groups by mesh size are given below. The number of lifts was about evenly divided between day and night sets and bait species.

Mesh size (inches)	No. lifts	Percentage by weight(average wt. per fish) Snappers	Groupers	Jacks	Other
1½	89	83.3	8.9	7.0	0.8
		(0.85)	(13.6)	(6.1)	(1.2)
2	90	75.4	15.8	7.6	1.2
		(1.18)	(12.8)	(6.3)	(2.8)

It is obvious that small mesh pots caught a higher proportion of snappers and a resultant lower proportion of the other groups. Snappers and jacks caught in small mesh pots averaged smaller, but groupers averaged slightly larger. No reason for this is evident.

Table 8.—Circumstances of good consistent trap fishing catch rates (where 10 or more lifts average 20 or more pounds per lift).

Location	Month-Year	Day (D) or Night (N) set	Pot type and mesh size	Depth range (fms)	No. of lifts	Lbs. per lift
Jamaica Banks						
S.W. Pedro Bank (30 mi. S.W. Blower Rocks)	Feb. 70	N	"D" 2"	20 - 22	25	24.4
Salmon Bank (on center ridge)	Feb. 70	N	"D" 2"	20 - 54	12	28.3
Albatross Bank (East and Southeast edges)	Feb. 70	N	"D" 2"	18 - 22	16	32.6
S.E. Pedro Bank (Southeast Peak)	Apr. 70	N	"Z" 1¼"	18 - 30	14	40.0
8-mile Bank (13 mi. West of Morant Cays)	July 70	N	"Z" 1¼"	22 - 27	76	22.4
S.E. Pedro Bank (Southeast Peak)	Nov. 70	N	"Z" 1¼"	18 - 27	42	20.4
North of Hispaniola						
Silver Bank (Southeast edge)	Jan. 70	N	"Z" 1¼"	10 - 20	12	36.8
	Jan. 70	D	"D" 2"	10 - 20	10	29.3
Navidad Bank (Southeast tip)	Jan. 70	N	"D" 2"	21 - 30	20	22.6
Mouchoir Bank (Southeast tip)	Jan. 70	N	"D" 2"	10 - 15	20	21.9
Northern Leeward Islands						
Barbuda Bank (N.W. slope)	Nov. 69	N	"O" 2"	43 - 52	11	21.7
Saba Bank (N. tip to N.W. slope)	Mar. 70	N	"Z" 1¼"	50 - 75	25	55.6
	Mar. 70	N	"D" 2"	50 - 75	38	34.0
Anguilla Bank (Northern slope)	Mar. 70	N	"Z" 1¼"	44 - 60	12	35.1
Barbuda Bank (N. and W. slopes)	Mar. 70	N	"D" 2"	50 - 65	17	30.6
Small Bank (11 mi. E. of Sombrero Bank)	Jun. 70	N	"Z" 1¼"	52 - 86	21	20.6
Saba Bank (Northwest slope)	Sept. 70	D	"Z" 1¼"	60 - 82	41	32.6
	Sept. 70	N	"Z" 1¼"	60 - 82	48	54.7
	Sept. 70	D	"Z" 2"	60 - 82	40	33.6
	Sept. 70	N	"Z" 2"	60 - 82	50	37.9
Barbuda Bank (North and Northwest slope)	Sept. 70	D	"Z" 1¼"	60 - 80	19	29.1
	Sept. 70	N	"Z" 1¼"	60 - 80	31	61.3
	Sept. 70	D	"Z" 2"	60 - 80	19	63.7
	Sept. 70	N	"Z" 2"	60 - 80	32	38.8
Saba Bank (Northwest slope)	Dec. 70	D	"Z" 1¼"	60 - 115	43	33.8
	Dec. 70	N	"Z" 1¼"	60 - 115	38	37.2
Anguilla Bank (East edge)	Dec. 70	N	"Z" 1¼"	30 - 55	37	31.2
Barbuda Bank (N. and N.W. slope)	Dec. 70	D	"Z" 1¼"	60 - 100	12	45.9
	Dec. 70	N	"Z" 1¼"	60 - 100	35	33.1
Saba Bank (Northwest slope)	Apr. 71	N[1]	"Z" 1¼"	65 - 80	27	54.5
South American continental shelf						
Guyana Shelf (43 mi. E. Waini Point)	Feb. 71	N	"Z" 1¼"	41	11	41.6
Venezuela (50 mi. N.E. × E. Orinoco Delta)	Apr. 71	D	"Z" 1¼"	55 - 63	19	24.5
	Apr. 71	N	"Z" 1¼"	55 - 63	29	20.3
Surinam (70 mi. N.E. Georgetown, Guyana)	Apr. 71	N	"Z" 1¼"	49 - 56	10	49.5
French Guiana (60 mi. N. Cayenne)	Apr. 71	D	"Z" 1¼"	45 - 65	38	33.0
	Apr. 71	N	"Z" 1¼"	45 - 65	38	64.3

[1]All traps in water 22 hours.

Soaking period

Calamar cruise 71-6 was planned as a specific experiment to observe the change in pot catch rate during soak periods varying from 1 to 5 days. Twenty "Z" pots and five "D" pots were set on a 1½ mile line in random order in 70 to 80 fathoms on the west side of the north peak of Saba Bank. All pots were of 1¼-inch mesh and were baited identically with about 5 pounds of robins. All pots were set in 1 day. Five pots (4 "Z", 1 "D") were hauled and reset the next day. The following day those same five pots were again hauled and reset the next day. The following day those same five pots were again hauled and a new group of five pots were also hauled. This latter sequence was continued for an additional 3 days. On the sixth day all pots were hauled and the experiment completed. Results were as follows:

Days in water	No. pots lifted	Total no. fish	Total lbs. fish	Average no. fish/ pot	Average lbs. fish/ pot
1	34	1509	1686	44.4	49.6
2	10	506	540	50.6	54.0
3	10	569	595	56.9	59.5
4	8	279	369	34.9	46.1
5	5	216	231	43.2	46.2

There is an increase of about 5 pounds per lift between 1 and 2 and between 2 and 3 days soaking, after which the catch rate declined back to about 46 pounds/lift. From the appearance of bait strings observed during the experiment, the rise and fall of catch rates was closely coupled to the time during which bait stayed available to the fish before falling off the wires and out of the trap.

DISCUSSION

The species composition of trap catches varied considerably throughout the region. A number of factors, including geographic area, fishing depth, mesh size, and to some extent, bait, affect the variation of species. The most important of these is felt to be the depth. Generally speaking, the species composition available to the pots will become less complex and the proportion of snapper will increase as the depth increases. Where it is not yet physically possible to fish pots on the precipitous bank peripheral slopes, fishing will be limited to the usually shallower edges and the species composition of the catch will be so affected and be more complex. It was found during our explorations that only the slopes of the banks in the northern Leeward Islands, and then only on the slopes facing away from the prevailing current (usually north and northwest), are gradual enough to permit pot fishing down to 100 fathoms and below. Consequently, in this area, catches were overwhelmingly dominated by silk snapper. This was most fortunate as this particular area appears to hold a high level of ciguatera type fish poisoning (Halstead 1970) which was not reported from any of the nearly 20,000 pounds of silk snapper caught from this area and sold by the project.

Because species composition is related to the sizes of fish retained by the pot, it will also vary with a change in mesh size. This is because a larger mesh size will allow small fish to escape from the trap, but will retain the larger (and usually more desirable) ones.

Mesh size can be applied as a fishery management tool also. During *Calamar* cruise 70-8 on Saba Bank, at one station 545 silk snappers were caught and measured. Twelve 2-inch mesh "Z" pots caught 223 of these, while

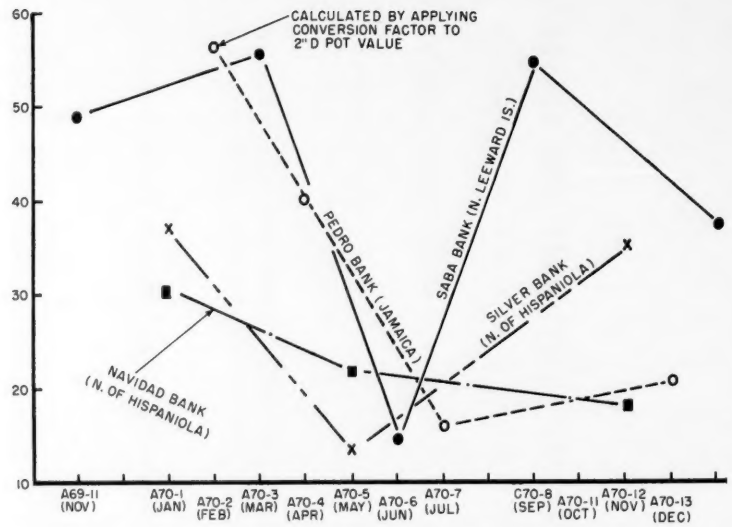


Figure 9.—Pot fishing catch rate (all catch rates obtained from overnight sets of 1¼-inch mesh "Z" pots) variations by month and location.

six 1¼-inch mesh "Z" pots caught 322. All pots were baited alike and set at the same depth. It was found that 96 percent of the silk snappers from the 2-inch mesh pots were above 24 centimeters in length, while only 50 percent of the silk snappers from 1¼-inch mesh pots exceeded 25 centimeters. As 24 centimeters represents the average length at maturity for this species (as determined by gonadal examination) 2-inch mesh pots would be excellent conservation gear for the species.

The catch rates given in Tables 3 through 7 are comprehensive in that they provide the full range of values as observed during all pot fishing explorations. In order to determine what constitutes a good or bad catch rate, certain parameters had to be applied. It was arbitrarily determined that catch rates in excess of 20 or more pounds per lift obtained from 10 or more individual lifts would be considered not only good, but also consistent catch rates. In Table 8, the circumstances including location, month, and year obtained, whether a day or night set, the pot type and mesh size, and the fishing depth range of all consistently good catches are given. This table becomes a reflection of the relative importance of the general areas of the region in that the number of entries from the northern Leeward Islands banks are highest, while the Windward Islands are not represented at all. It can also be seen that the majority of good catches were made by 1¼-inch mesh "Z" pots fished at night in generally deeper water.

Seasonal availability (to fish traps) can be determined by examining the variations in the catch rates by the month they were observed. Seasonal abundance can be inferred from these data providing other seasonal factors that might inhibit fish from being trapped did not prevail. In Figure 9, the variations in catch rates by cruise (month) from four banks representing three areas are shown. All data were obtained from overnight sets of 1¼-inch mesh "Z" pots. Although all changes are not the same there appears to be an overall reduction in catch rates (availability) occurring during May-June-July, with relatively higher rates during the remainder of the year. The period of reduced catch rates corresponds with the period of seasonal warming in waters of these areas.

Although pounds of fish per lift is an acceptable measure of fishing effort for determining potential, the amount of fish available to a vessel using fish pots will be limited by the number of pots that it can effectively work in a day or any other time period. Pot setting and hauling is generally limited to daylight hours although it is possible (though not desirable) to set pots in darkness. By examining Table 5, it will be seen that when a pot is set and hauled twice a day, its total catch will greatly exceed the catch if hauled only once a day (as in *Calamar* cruise 71-6). This was determined early during pot fishing explorations and two sets in 24 hours became standard procedure when the boat stayed in one location. It was also determined that during normal operations a pot could be lifted, emptied, rebaited, and reset in 10-15 minutes. Therefore, if pots were handled twice a day and took an average of 10-15 minutes each to handle, the maximum number of pots to be worked daily would be between 15 and 20. This would require 8-10 hours, which is about maximum, particularly if fish are being dressed and stored between morning and evening hauls. This number of pots was also convenient for *Calamar* and *Alcyon* as they could carry about 24 assembled "Z" pots on deck at a time, which provided an ample number of spare pots to replace those lost or damaged.

SUMMARY AND CONCLUSIONS

In summary, project pot fishing for snappers and related demersal species in the Caribbean and adjacent waters has displayed generally good potential. In all areas possessing offshore banks or shelves of any magnitude, the catch rates have been high enough to evoke commercial interest. While the smaller banks off Jamaica would probably not support unlimited effort because of size, Pedro Bank is large enough to provide a continuously good ground for Jamaican fishermen. The eastern end of the bank receives some small effort presently, but it is by small canoes carrying a few traps. The southern and western sides of the bank are almost untouched. Silver and Navidad Banks both display good trap fishing potential. In the northern Leeward Islands, Saba and Barbuda display excellent potential, while Anguilla Bank is also good. Gibbs Seamount

has demonstrated potential that must be limited because of size. In the Windward Islands, the Grenada Shelf has shown some moderate potential. Good potential was observed off eastern Venezuela, Guyana, and Surinam. Excellent potential was found off French Guiana.

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MFR PAPER 1088

Exploratory Tuna Longline Fishing in the Caribbean and Adjacent Waters

KYOTARO KAWAGUCHI

ABSTRACT—This report gives the results of tuna longline exploration conducted by the Caribbean Fisheries Development Project. All such fishing was conducted in the Caribbean Sea and adjacent Atlantic Ocean waters in 1966 and 1967. Background information, including the fishing history, topography, oceanography, fishing grounds, and seasons, is given. Vessels and gear are described, after which fishing results are presented by geographic region. Overall results were generally poor and below commercial catch rates observed in the same regions for a variety of reasons. In summary, the resource was considered insufficient for the establishment of a continuous tuna longline fishery in the Project region.

INTRODUCTION

This report is one of a series on exploratory fishing activities of the Caribbean Fisheries Development Project which became operational in August 1965. Although the tuna resources in the Caribbean waters had already been explored by the United States (since 1954) and by Japanese research vessels and commercial vessels (since 1955), the fishery is utilized only seasonally by foreign vessels. This type of fishing was adopted by the Project to evaluate its potential for fishermen of the Caribbean Region.

BACKGROUND OF TUNA LONGLINE FISHING IN THE CARIBBEAN

History

The U.S. Fish and Wildlife Service's exploratory fishing vessel *Oregon* carried out tuna longline fishing in April and May 1955, January 1956, and August, September, and October 1957, to determine the extent of subsurface tunas in the northern, western, and eastern Caribbean, and to gain information on the possible continuity of yellowfin tuna stocks between the Gulf of Mexico and the Caribbean.

Several Japanese longliners conducted commercial feasibility operations in the Caribbean between 1955 and 1958. The results were encouraging in catch rate and there was less distance to vessel bases when compared with the Pacific or Indian Ocean operations. In 1958, 51 vessels caught 30,984 tons during 131 cruises. In 1961, total vessels operating in the Atlantic were 86 with 82,251 tons caught during 258 cruises.

This increase continued until about 1964 with a final total of over 100 vessels involved. Some of these vessels, however, started to move to the Indian and Pacific oceans due to uneconomical operating conditions. Factors included a change of market, labor problems, and decrease in catch rate. In 1968, the vessels operating in the Atlantic decreased to about 25. Dominant size of those Japanese tuna longliners in the Atlantic is about 300 to 400 gross tons (GT). The larger sized vessels—more than 500 GT—usually carried one or more catcher boat(s) which could independently operate 200 to 250 baskets of longline gear each. Longline gear used by those vessels was mostly the same type as that used by the Project vessels mentioned in this report—400 to 450 baskets set per day by the commercial vessels.

Some of those vessels worked in the Caribbean during seasons when higher catch rates of tuna were possible. In the earlier stages of fishing, landing bases existed at Trinidad, Panama, Haiti, Cuba, Colombia, and Brazil. Recently there has been only one land-and operating base—St. Maarten.

In Venezuela, some of the local fishing vessels started tuna longline fishing in the eastern Caribbean about 1954. As a result of the *Bosu Maru* exploratory tuna longline fishing based at Venezuela, a Venezuelan-Japanese company was established in 1957 to initiate the fishing with two Japanese-built longliners which were manned by mixed crews. Successful operations of this company and favorable demands for tuna in Venezuela stimulated local vessel owners to increase modifications to longliners. In 1966, there were about 43 vessels, mostly 3 to 45 tons in capacity, fishing with an average of 100 to 120 baskets of Japanese-type longline. Annual landings in Venezuela from 1960 to 1966 ranged from 1,940 to 3,540 tons. The seasonal and annual change of yellowfin and albacore in the Caribbean and western Atlantic was studied, based on data collected from three longliners from 1960 to 1963.

In Cuba, a Japanese commercial longliner (462 GT) started demonstra-

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tion tuna longline fishing from Havana in 1957. Three similar vessels joined the following year. After the new government took over, the Cuban Fishing Fleet Enterprise started tuna longline fishing with five medium sized tuna longliners acquired from Japan in 1962, and a continuous increase of this type of vessel—250 to 600 GT—brought the number of longliners to 28 in 1967. These vessels are equipped with Japanese-type longline gear of 280 to 330 baskets (5-hook) and operate in the Gulf of Mexico for yellowfin tuna, the Atlantic and Caribbean for tunas and marlins, or east of the Florida coast for bluefin tuna. Working rate trip norms for the tuna longliner in 1967 showed 85 to 90 days at sea with 62 to 66 days fishing to produce 115 tons per trip.

In Puerto Rico, a research vessel, *Carite*, conducted exploratory tuna fishing in the Mona Passage and northern waters of the island from August 1963 to June 1965. A total of 13 longline sets with 100 to 300 hooks per set in the eastern part of Mona Passage captured no tunas. A more satisfactory result was obtained by trolling for blackfin, skipjack, and small yellowfin tunas. A few sets north of San Juan and east to the Virgin Islands resulted in one fish/100 hooks for yellowfin and albacore tunas. Other data from around Puerto Rico indicates a catch rate of 0.38 fish/100 hooks calculated from a total of 20 tunas from 5,236 longline hooks fished by MV *Crawford*, MV *Oregon*, MV *Elmer*, etc., since 1957. In 1958, there were 18 tuna purse seiners based in Mayagüez and Ponce, Puerto Rico. They fished primarily from northern Chile and northern Mexico in the eastern Pacific and the Atlantic off Africa from the Gulf of Guinea to Angola, with some seasonal fishing from Cape Hatteras to Cape Cod.

Topography

The Caribbean is bordered by Central and South America, and the Greater and Lesser Antilles. The sea is separated from the Atlantic proper by ridges of the Antilles arc. The region is divided into two major regions by the Jamaica Rise which extends from Hispaniola to Honduras. The eastern region of the sea is partially separated into two basins: Colombia Basin in the west, Venezuela Basin in the east, and by the Beata Ridge which extends south to about lat. 15°N. The Aves Swell, which extends from lat.16°N to 12.5°N at about long.63.5°W, separates the Grenada Trough in the east, and beyond the ridges of the Lesser Antilles, farther east, a small trough, the Tobago Trough, exists between the Grenadines and Barbados. The Los Roques Trench in the south of the basin is closely adjacent to the Venezuelan Shelf. The Cayman Trough and Yucatan Basin are in the western region of the Caribbean Sea. The major openings with great sill depths are the Yucatan Channel between Cuba and Yucatan, Windward Passage between Hispaniola and Cuba, Anegada and Jungfern Passage between the Virgin Islands and the Leeward Islands, and between the north Virgin Islands and St. Croix. The Mona Passage between Hispaniola and Puerto Rico has a very shallow sill depth and there are many narrow openings between the islands on the Lesser Antilles arc from the Leeward Islands to the coast of South America with relatively shallower depths.

Oceanography

The main ocean currents in the Caribbean Sea and the adjacent waters are the North Equatorial Current, South Equatorial Current, Equatorial Countercurrent, Antilles Current, Florida Current, and Gulf Stream. The North Equatorial Current flows to the west from Africa and near the Antilles divides into two parts, one of which flows into the Caribbean and joins the Florida Current passing through the Gulf of Mexico; the other branch becomes the Antilles Current proceeding northward, rejoining the Florida Current north of Cuba. In the winter, the south boundary of this current is about lat. 5°N in the northern waters of Brazil. In summer, the boundary moves up to about lat.10°N. The Antilles Current is stronger in the summer. The South Equatorial Current flows west with a northern boundary of about lat.5°N in winter, and splits where some of the current changes direction to northwest and runs along the northeast coast of South America to join the North Equatorial Current in the Caribbean. The rest becomes the Brazil Current which runs south along the southeast coast of the continent. In summer, the northern boundary of the South Equatorial Current goes south to about lat.3°N and in between the North and South Equatorial Currents or about lat.3°N and 10°N, the Equatorial Countercurrent appears and flows from west to east.

Accordingly, the main current in the Caribbean is formed by both the North and South Equatorial Currents and both sides of the main current have many eddies. One of the eddies is between Nicaragua and Colombia and another between Cuba and Jamaica. This main current flows into the Gulf of Mexico through the Yucatan Channel and becomes the Florida Current which runs clockwise around the Gulf and flows north to Cape Hatteras after passing through the Straits of Florida. The Florida Current and the Antilles Current join together and make the Gulf Stream.

The species of tunas living in these currents are as follows:

Current	Tuna species
N. Equatorial Current	albacore, bigeye tuna
S. Equatorial Current	yellowfin tuna and albacore
Equatorial Countercurrent	yellowfin tuna, bigeye tuna, and bluefin tuna
Gulf Stream	albacore
Brazil Current	albacore and blue marlin

Fishing Grounds and Seasons in the Caribbean and Adjacent Waters

Although there are some differences in the catch rates and distances to Atlantic fishing grounds from the Caribbean Islands, the seasonal migration of tuna is more regular than that in the Caribbean. Fishing effort in number of hooks set by Japanese tuna longliners and catch rates by number of fish for tuna species in the Atlantic from 1956 to 1962, are shown as follows:

	Number of fish per hundred hooks			
Year	Albacore	Bigeye tuna	Yellowfin tuna	No. of hooks
1956	0.8	0.1	0.9	0.13×10^6
1957	0.9	0.2	7.6	3.37×10^6
1958	1.2	0.2	9.3	7.98×10^6
1959	2.3	0.3	7.1	15.23×10^6
1960	2.2	0.3	5.6	20.90×10^6
1961	1.6	0.9	3.7	26.40×10^6
1962	2.0	0.7	1.8	54.10×10^6

[1]1965	2.4	0.4	0.6
[1]1966	2.2	0.3	12.
[1]1967	3.8	0.3	0.8

[1] Catch rate for the area between lat. 10°N and 40°N and from long. 40°W calculated from the Graphic Report of Recent Fluctuation Trends of Tuna Hooking Rate by Area (Tuna Fishing, No. 78).

According to the above statistical data provided in the *Annual Report of Every Ten-days' Tuna Fishing News*, 1964 to 1968, and data of *Tuna Fishing* for the last several years, the general movement of albacore, yellowfin tuna, and bigeye tuna in the Caribbean and adjacent waters can be outlined as follows:

Albacore—The season starts in April northeast of Puerto Rico, about lat. 25°N to 30°N, then moves southwest and in May to June reaches the Puerto Rico Trough, then moves southeasterly along the Atlantic side of the Lesser Lesser Antilles arc from July to September. About October or November some albacore fishing grounds are found in the water north of Guyana and Recife, Brazil, then they disappear to the south. During the movements from June to September some influx of albacore into the Caribbean occurs over the deeper sill openings. Accordingly, during a year when this influx has taken place the albacore season begins in the northeastern region of the Caribbean about May to June for a short period, then resumes again in the southern waters of Hispaniola and Jamaica in about October to November mixed with yellowfin tuna. It moves southeasterly and about January disappears from the Caribbean Sea.

Yellowfin tuna—The season starts in the south about April to May from off Guyana then moves to the southeast region of the Caribbean about May or June, the catch being mixed with some albacore. It may last as late as December. In some years good fishing occurs between Colombia and Nicaragua. This may occur from August to September or in January to February. Meanwhile, in the Gulf of Mexico, a high catch rate of yellowfin tuna is expected for a few months around July.

Bigeye tuna—Though it is not common in the Caribbean, some catches are expected in the eastern and southern water of the Lesser Antilles during the winter months.

Bluefin tuna—In May to June, bluefin tuna appear in the northern waters of the Bahama Islands or eastern waters of Florida with a high catch rate by weight.

Other—There is an abundance of white marlin in the Caribbean from February to October with a peak about June, and blue marlin are present in the longline catch in the Caribbean from June to October.

Trends of the daily total catch in weight by longliners (about 2,000 hooks per day per vessel) for 4 years in the Caribbean and adjacent waters are as follows:

Tuna catch in metric tons/day

Month	1964	1965	1966	1967
Apr.-May	3.6-3.0	2.6	1.6	2.4-2.6
Jun.-July	3.0-2.6	2.4-2.2	1.9-2.8	2.2-2.8
Aug.-Sep.	2.1-2.3	2.8	2.9-3.0	1.8-1.2
Oct.-Nov.	2.8-2.6		1.9-2.3	1.0-1.4
Dec.-Jan.			2.0	1.6

EXPLORATORY LONGLINING BY PROJECT VESSELS

From December 1966 to August 1967, two Project vessels, *Calamar* and *Alcyon*, conducted 10 cruises for tuna with longline gear, fishing in the Caribbean Sea and adjacent waters.

Vessels and Gear

Calamar and *Alcyon* are sister vessels with the same dimensions and equipment, being built in 1966 for multipurpose exploratory fishing and training.[1] They are equipped with radar, direction finder, radio, automatic pilot, and with hydrographic winch, trawl winch, tuna longline hauler, and portable live bait tanks. The *Calamar* normally operated from Barbados while *Alcyon* was based in Jamaica.

The longline gear utilized was of Japanese design. It consisted of a 210-fathom main line with six branch lines placed at 30-fathom intervals. Each such unit is called a basket. The branch line has a total length of 13 fathoms which is composed of 8 fathoms of line (the same material as the main line), 3½ fathoms of sekiyama wire (consisting of a wire core served with cotton twine), and 1½ fathoms of leader wire with a hook at one end. A brass box swivel connects the line and the sekiyama. The main line and branch lines are made of Kuralon (Polyvinylalchol) 20'S/55 × 3 × 3 (about ¼ inch in diameter) rope, treated with coal tar. The sekiyama wire has a Standard Wire Gauge (SWG) 26 no. × 3 × 3 core wire rope and is served with Kuralon twine 20'S/5 × 3. The leader wire is of the same material as that of the sekiyama wire core. The swivel is 3 inches long and the hook is 4½ inches in total length (No. 38 by Japanese standard) of Birmingham Wire Gauge (B.W.G.) 6 in diameter at the thickest part. Breaking strain of the line is about 500 pounds and that of the wire about 420 pounds.

[1] See paper by Wolf and Rathjen, this number, for photographs and specifications.

Many baskets of longline are connected end to end to make a long continuous line for a set while shooting the line from the moving vessel. The longline is suspended from the surface by buoys and tied to a 15 foot bamboo pole marker at each junction of the baskets.

Typically, setting of the gear takes place early in the morning, then retrieving begins about midday after 4 or 5 hours drifting. The hooks are baited with herring (*Clupea harengus*), fourwing flyingfish (*Hirundichthys affinis*), or Pacific saury (*Cololabis saira*).

Fishing Regions and Seasons

From December 1966 to August 1967, the *Calamar* covered the southeast area of the Caribbean and the adjacent Atlantic water north of Guyana and Surinam. The *Alcyon* worked the central to northeast area of the Caribbean, the adjacent Atlantic water, and the northern half of the Lesser Antilles. Since the areas were mostly covered in different months, the results by regions are presented in two periods: January-June and July-December.

In view of topographic characteristics and oceanic currents in the Caribbean and adjacent waters, the water covered was divided into five

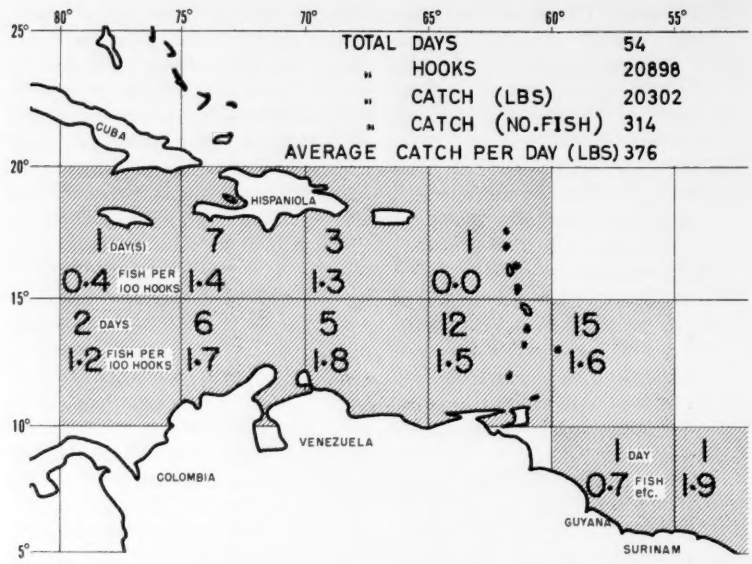

Figure 1.—Project tuna longline catch rates by area for January through June.

regions, namely: Jamaica North; Central North; Central South; Northeast Region; and Southeast Region; and adjacent waters covered were classified into five sections as: West Haiti; Northeast of Dominican Republic; Anegada Passage; Atlantic water east of northern half of the Lesser Antilles; and Atlantic water east of southern half of the Lesser Antilles section.

Catch rates by Project vessels are shown in Figures 1 and 2. Catch rates are given as the number of fish per 100 hooks of gear set. All catch rates in the succeeding text are in number of fish per 100 hooks.

Jamaica North Region

In December 1966 a total of four longline sets utilizing 516 hooks was made by the *Alcyon*. Two sets were in deep water near the Cayman Islands, one set off the north coast of Jamaica and one set in the south opening of the Windward Passage. These produced only six tunas (four yellowfin, one bigeye, and one bluefin tuna) at an average rate of 1.2 tuna, or at the rate of 0.8 fish for yellowfin tuna. Two of the four yellowfin tuna were caught near the Cayman Islands and two were caught in the Windward Passage. One bluefin tuna weighing 462 pounds was caught off the north coast of Jamaica. Surface water temperatures in this region ranged from 81.0 to 81.7°F, and the currents observed were mostly easterly. A total of three blue marlin weighing 499 pounds was captured along with the tuna during the period. One set of 250 hooks in February caught no tuna, but caught one white marlin weighing 40 pounds. The surface water temperature was 80.5°F and the current was observed to be northeasterly.

Caribbean Central North Region

A total of three longline sets was made by the *Alcyon* in December 1966 in the southern water off Haiti, and four sets were made in February 1967 off the east and south coasts of the Dominican Republic. The December sets with a total of 555 hooks captured four tunas: three yellowfin tuna and one albacore, at an average of 0.7 fish or 0.5 yellowfin tuna only. The surface temperature was 81.9° to 82.4°F, and the currents observed were northeasterly near the coast and westerly offshore. In February, three sets with a total of 1,170 hooks captured only one yellowfin tuna south of Pta. Beata, Dominican Republic. The surface temperature ranged from 79.7° to 80.2°F and a strong easterly current was observed south of Pta. Beata. One blue marlin weighing 235 pounds and two white marlins of 112 pounds total weight, were caught from one set southwest of the Mona Passage.

West Haiti/Northeast Dominican Republic Region

In the waters adjacent to Jamaica's North region, five tuna longline sets utilizing 1,590 hooks were made by *Alcyon* in Gonave Gulf, west of Haiti, in February. Fourteen yellowfin tuna were captured at catch rates from 0.3 to 1.2 fish. The surface water temperatures were higher than those in other areas during this month at 81.1° to 81.9°F, and the salinity ranged from 35.70°/$_{oo}$ to 35.84°/$_{oo}$ at surface and 36.48°/$_{oo}$ (at 70°F) to 36.91°/$_{oo}$ (at 71°F) at about 600 ft depth. Thermocline depths were from 220 to 310 feet. The sizes of yellowfin tuna were smaller ranging from 114 to 132 cm but mostly less than 130 cm. Seven blue marlin weighing 1,004 pounds, four white marlin weighing 195 pounds, and three longbill spearfish weighing 112 pounds were also taken from the five sets.

Northeast of the Dominican Republic, one set of 260 hooks took only one yellowfin tuna and one longbill spearfish. The surface water temperature was low at 78.8°F with a salinity of 36.14°/$_{oo}$ and the thermocline existed at about 380 feet. The salinity at about 600 feet was 36.70°/$_{oo}$ at 70°F. The size of the yellowfin tuna was 131 cm and the longbill spearfish weighed 33 pounds.

During January 1967, *Alcyon* made nine sets utilizing 2,405 hooks and *Calamar* completed three sets with a total of 1,230 hooks during the same month. The *Alcyon* caught seven (plus two lost) yellowfin tuna, four bigeye tuna, and one albacore, for a total average catch rate of 0.5 tuna. *Calamar* produced five yellowfin, one bigeye tuna, and one albacore at the rate of 0.6 tuna from the eastern end of the region. The yellowfin tuna taken were comparatively larger ranging from 126 to 160 cm. Four of them were over 154 cm, and bigeye tuna ranged from 143 to 148 cm in fork length. The surface water temperature ranged from 78.1° to 80.9°F, with lower temperatures in the southwestern area of the region. The depths of thermocline ranged from 90 to 300 feet with some correlation of lower surface temperature to shallower thermocline. The salinities in the western area of the region ranged from

35.89°/$_{oo}$ to 36.14°/$_{oo}$ at the surface and 36.13°/$_{oo}$ (19.4°C) to 36.65°/$_{oo}$ (at 18.7°C) at approximately the 600-foot layer. Additionally, from those sets *Calamar* caught 12 white marlin and the *Alcyon* took four blue marlin, four Atlantic sailfish, and six longbill spearfish.

Caribbean Northeast Region (Anegada Passage)

The *Calamar* made one set of 354 hooks in January 1966 in the southern area of this region but caught no fish. The surface water temperature was 79.5°F and thermocline depth was about 260 feet. In August 1967, *Alcyon* made a set of 540 hooks west of Dominica Island and another set of 588 hooks further southwest of Puerto Rico on the way back from Atlantic tuna fishing operations. Near Dominica, no tuna was caught in comparison with seven tunas caught at almost the same distance east of Dominica. The surface water temperatures were the same (80.2°F) at both locations, but the thermocline depth was 130 feet on the Caribbean side and 240 feet on the Atlantic side. Further westward a set took 12 tunas—7 yellowfin, 2 bigeye, 2 albacore, and 1 blackfin tuna—for an average of two fish. The color of the water was bluish/dark green and the surface water temperature was 82.8°F. The thermocline depth was about 160 feet from the surface. In the Anegada Passage, the *Alcyon* made three sets utilizing 1,680 hooks close to Sombrero Island in August 1967, and caught 16 tuna—5 yellowfin tuna, 9 albacore, and 2 large skipjack tuna—a total tuna catch rate of one fish. The surface temperatures were 82.9°F and the thermocline depth was 160 to 180 feet. The current was west-northwesterly.

Caribbean Southwest Region

In December 1966, four sets utilizing 930 hooks, and in January 1967, six sets utilizing 2,328 hooks were made by the *Calamar* in this region. In the December sets, four yellowfin tuna and one albacore were taken at rates of 0 to 1.2 fish around lat. 13°N west of St. Vincent. In the six sets in January, three yellowfin tuna, two bigeye tuna, and two albacore were caught at the rates of 0 to 1.4 tuna. Five sets out of the total 10 sets took no tuna in this region. Surface water temperatures ranged from 81.2° to 82.5°F in December and from 79° to 79.7°F in January and the thermocline existed at about 100 feet in December and 100 to 180 feet in January.

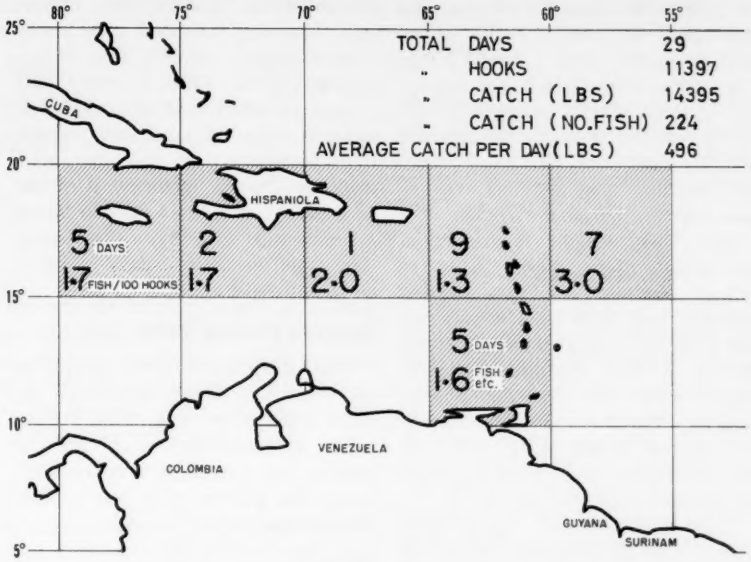

Figure 2.—Project tuna longline catch rates by area for July through December.

Atlantic Windward Islands Region

During December 1966, one 180-hook set took no fish just east of St. Vincent. The surface water temperature was 83°F and a thermocline existed at about 100 feet. In January, the *Calamar* made another set of 420 hooks south to lat. 12°N east of Grenada and caught six tuna: four yellowfin tuna and two bigeye tuna together with seven white marlin, at a rate of one yellowfin and 0.5 bigeye tuna. The surface water temperature was 79.9°F and thermocline depth was about 120 feet. A current in the area was west-northwesterly. The sizes of the yellowfin were relatively small at 124 cm and 129 cm. In February, 10 sets utilizing 4,002 hooks between southern Lesser Antilles arc and long. 55°W, were taken. Out of the 10 sets, one set in almost the same position as January's took two yellowfin tuna and two bigeye tuna at a rate of 0.4 fish for either species, the surface water temperature being lower at 78.1°F with a shallower thermocline at about 70 feet from the surface. Another three sets around the position caught no tuna and those surface water temperatures and thermoclines from near the Antilles Ridge to offshore were 78.8°F - 110 feet, 79.7°F - 210 feet, and 79.9°F - 260 feet, respectively. One set further east on lat. 12°N took only one albacore for 378 hooks, where the surface water temperature was 79.7°F and thermocline was 250 feet deep. Five of the 10 sets along lat. 13°N caught five yellowfin tuna and one bigeye tuna at rates from 0 to 0.7 fish. The lowest surface water temperature was 79.2°F.

Atlantic Leeward Islands Region

In this region, from 25 July through 16 August 1967, the *Alcyon* made six sets in July and five sets in August. The sets in July ranged in distance from 17 miles northeast of Barbuda Island to 180 miles east of Guadeloupe, the average catch being 2.4 fish for tuna, ranging from 1.0 to 4.6 fish. The average catch rate for yellowfin tuna was 0.5 fish with a range of 0 to 1.0 fish and the same for albacore was 1.7 fish. Among the species, only two bigeye tuna and two blackfin tuna were caught from all of the sets. The five sets in August ranged from 30 miles east of Dominica Island

to 210 miles east of Antigua and the catch rate was 2.0 fish at an average ranging from 1.3 to 2.3 fish. The yellowfin tuna catch rate was 0.4 fish average with a range from 0.2 to 0.6 fish and the same for albacore was 1.4 fish. Only one bigeye tuna, two blackfin tuna, and one skipjack tuna were taken from the five sets.

The fork length frequency of yellowfin tuna was: 14 fish from 137 to 145 cm; two fish from 130 to 135 cm; one fish from 110 to 114 cm; two fish from 58 to 60 cm; four fish from 145 to 149 cm; and three fish more than 150 cm. The same for albacore was: five fish from 89 to 92 cm; 37 fish from 93 to 100 cm; 27 fish from 101 to 104 cm; and 17 fish from 105 to 122 cm.

The surface water temperature ranged from 81.2° to 81.5°F in July and 81.3° to 82.4°F in August, and the thermocline's depth ranged from 100 to 160 feet in July and 130 to 240 feet in August.

FACTORS AFFECTING CATCH RATE

There are a number of factors which affect longline catch rates. These include (1) amount of gear set, (2) total time gear is fishing, (3) fish behavior, (4) oceanographic conditions, (5) bait, and (6) gear arrangement. The following generalities were observed when Project longlining efforts were compared with those used in regular commercial practice.

Amount of Gear Set

The amount of gear set seems to be the most influential factor on the catch rate. Not only is there an expected rise in the total catch, but also a rise in the catch rate has been observed as the amount of gear set (and fished) over a given time period is increased. Typically, commercial tuna longliners of 200 GT and over operate 400 to 450 baskets (about 2,000 hooks) per day. This is about maximum considering the time required for hauling and setting. Project vessels, however, were able to average only 68 baskets and 390 hooks per day while expending the same time setting and retrieving the gear.

Depending on surface and subsurface currents, a commercial set would stretch 46 to 52 miles long. Project sets, however, stretched only about 9 miles, about one-fifth that of the commercial set. Thus, it would take 5 days for such a small scale operation to cover the same area covered by a commercial set in 1 day. Further, by Project methods, it might be expected to take 15 days to locate a good setting area that a commercial ship would locate in 3 days, which is an accepted average.

Elapsed Fishing Time

The total time that the gear is in the water and fishing influences the catch rate. Because it took Project vessels the same amount of time to retrieve less gear than a commercial vessel, the average time that a hook was available to fish was less.

Other

There should be no difference in individual fish behavior as it relates to commercial or Project longlining. This applies also to oceanographic conditions, bait (all purchased from the same source), and gear arrangement.

SUMMARY

Considering the recent standstill trend of the commercial tuna longline fishery in the world and the disappointing results from the Project vessels, the Project has come to the conclusion that for subsurface tuna and related species in the Caribbean, only a limited quantity of these species exists throughout the year. Some increase in quantity takes place on a seasonal basis, but with an uncertain large annual variation which only sometimes falls within the limits of a commercial quantity available to the tuna longline method. In general, the resource is considered insufficient for establishing a continuous tuna longline fishery in the Project region.

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MFR PAPER 1089

Results of Experimental and Exploratory Shark Fishing off Northeastern South America

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ABSTRACT—This paper describes the results of eight exploratory and experimental shark fishing cruises on the South American continental shelf off the Guianas. The types of gear used are described and an evaluation of the catches by gear, area, depth, season, species, length frequency, and length/weight correlation is given. The average catch per day for the area fished was roughly 3,000 pounds of dressed shark meat.

INTRODUCTION

During the second UNDP/FAO Caribbean Fishery Development Project Liaison Officers Meeting in September 1967 the participants were given a paper entitled "A proposal for harvesting sharks in the West Indian Area" (Rathjen 1967). The proposal was approved and a survey of shark availability was subsequently carried out during eight cruises conducted by the project vessel MV *Calamar* within the period December 1968 to August 1970. The area covered during the explorations was the north coast of South America from the border of Brazil in the east to the territorial waters of Trinidad in the west.

The purposes of the survey were: to obtain data about abundance and availability of sharks in the Guiana area; to evaluate shark fishing methods and teach local fishermen how to use them; and to provide the marketing section of the project with raw material for food processing and marketing demonstrations.

In 1945, an Anglo-American Caribbean Commission prepared a guide to commercial shark fishing in the Caribbean in which they described the species to be caught, how and where to fish, and which parts of sharks were useful, etc. (Anglo-American Caribbean Commission 1945.) This report was provided at a time when there was a major interest in shark fishing because the livers contain vitamin A which could not then be made synthetically. Since synthetic vitamin A can now be produced economically, the shark fishery has dropped off sharply. Prior to this synthetic vitamin A, shark fishing on a commercial scale was carried on from Barbados and Trinidad (Hsu, Kleijn, and Rathjen 1969).

Present shark fishing in the UNDP/FAO Caribbean Project region is of a limited nature. In the 1969 Statistical Yearbook of the United Nations the following figures are given:

Member countries of UNDP/FAO Project:

Trinidad and Tobago	1,100 metric tons
Martinique	100 metric tons
French Guiana	100 metric tons
Grenada	< 100 metric tons

Countries in the project area, but not members:

Cuba	2,600 metric tons
Venezuela	2,500 metric tons
Colombia	100 metric tons (probably most out of the Pacific Ocean)
Dominican Republic	< 100 metric tons

Besides these official figures it is known from local sources that small amounts of sharks (less than 100 metric tons annually) are landed in Surinam, Guyana, Barbados, and the Windward and Leeward Islands.

GEAR AND METHODS

Fishing Gear

During the exploratory fishing operation several types of gear were used. During the first four cruises steel cable setline, handline, the bottom longline, Cuban longline, and modified tuna longline were all tested experimentally. During subsequent cruises only the steel cable setline and handlines were used.

Steel cable setline (Fig. 1)

This gear consisted of a 3/8 inch diameter steel cable 3,000-5,000 feet in length. On this cable at 30-foot intervals, two 5/16 inch wire clamps were fastened about 6 inches apart. Between these two clamps, a 10 foot chain branch line with a Mustad[1] 2½-inch shark hook was attached with a snap fastener (Fig. 2). In total 100-175 hooks were used at a time. Figure 1 shows how the steel cable is operated during setting. The cable (D) which is stored on a drum of the trawl winch (A) is run over the fair leaders (B) to the rollers (C). A marker buoy (G) (Fig. 3) and a light buoy (H) are attached to the end of the line. The cable is then run out for a variable length depending on the depth. Next the anchor (F) is hooked to the line and this is followed by snapping on the individual baited hooks on chain leaders (E), then another anchor is snapped on and again a buoy and a light are attached to the end. Lights were used because the setline was generally soaked overnight. The line was soaked from 6 to 16 hours.

During cruise 70-7 an experiment was conducted in order to compare the catch from a full overnight set of the steel cable setline with two sets within about the same time period. Because only one steel cable setline was available the overnight set was followed the next night by two sets of about equal duration at the same depth and in the same general area.

Retrieving of the line is as follows: the buoys on one side are picked up and the end of the cable is attached to the drum of the winch and while retrieving the first anchor, hooks, second anchor, and buoys were consequently unsnapped (Fig. 4). When a big shark was brought alongside it was gaffed

[1] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

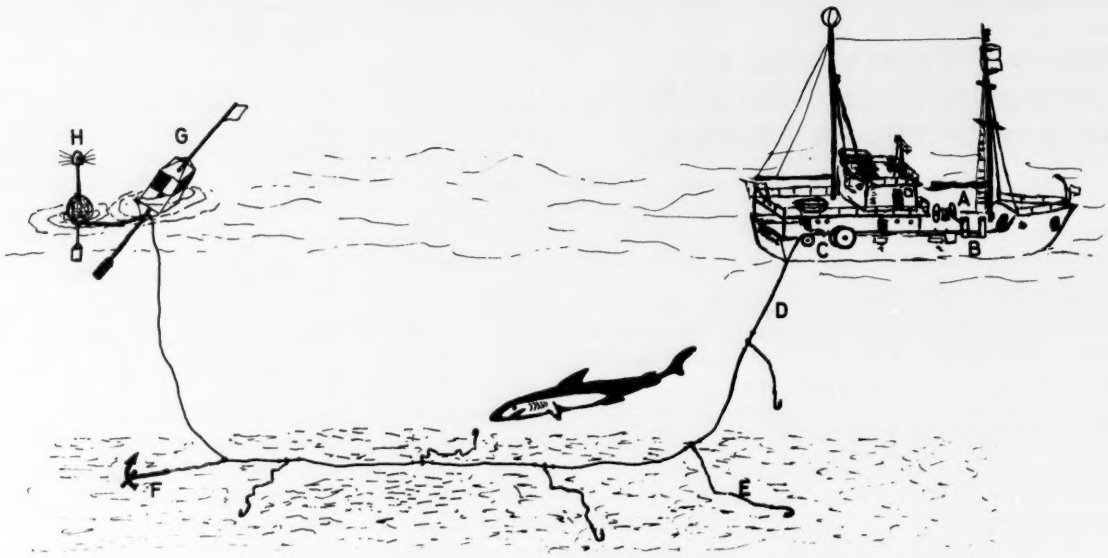


Figure 1.—Steel cable bottom setline gear used for shark fishing.

and then hoisted on deck with the help of a single wire whip attached to the mast.

Handline

A shark handline (Fig. 5) consisted of a coil of tuna longline rope (30 fathoms of ¼-inch tarred Kuralon rope) (A) with an 8-inch trawl float attached 2 to 3 feet from one end (B). At the same end a steel leader (C) (3 feet of ⅛-inch stranded stainless steel) with a tuna hook (D) (No. 38, Japanese measurement) is secured. One to eight individual lines were used during fishing operations. The handlining was conducted mostly after a bottom trawl haul, using a 40-foot shrimp trawl, as this often attracted sharks to the ship. Part of the crew sorted out the trawl catch while others threw out handlines from the drifting vessel. During the handlining operation scoops of trash fish were occasionally thrown overboard to attract the sharks. After the trawl catch was sorted, the entire crew alternated at handlining or gutting and dressing (Fig. 6) sharks already caught in order to keep the meat in prime condition.

Ten to 20 baskets of standard tuna longline (six hooks per basket) were anchored to the bottom and marked with buoys and lights as with the steel cable setline. A basket of longline was composed of seven mainline sections each 30 fathoms long and the hooks were attached to the end of 11½-fathom-long branchlines. Bottom longlines were usually fished with the steel cable setline at the same station for comparison.

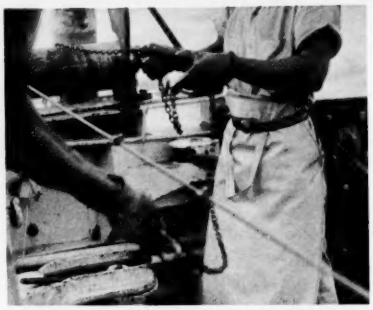


Figure 4.—Retrieving the steel cable setline.

Figure 2.—A chain branch line with shark hooks attached.

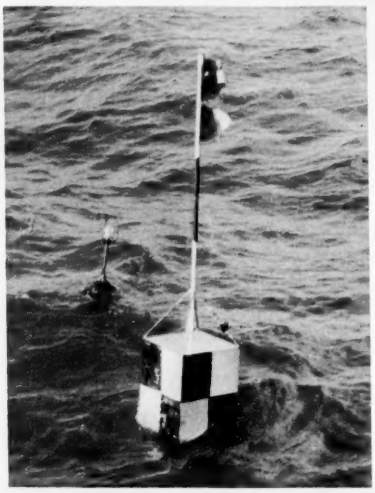


Figure 3.—Marker buoy and light buoy.

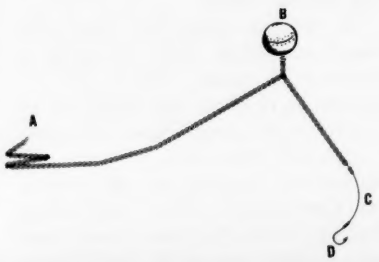


Figure 5.—Handline gear used for shark fishing.

Modified tuna longline

From 23 to 35 baskets of tuna longline, same construction as bottom longline, were used with a float at the end of each basket (float lines 12 fathoms long) and lights were used to mark the ends of the total line. These drifting sets were conducted on the edge of the continental shelf in deep water.

Cuban shark longline

The Cuban shark longline is a drift longline modified for shallow water use. It consists of 20 baskets with four hooks each. Normal drift longline is 23½ fathoms measured from the top float to the deepest point (hook) in a straight line, while the Cuban longline is only 11 fathoms and the mainline does not sag so much because of an extra float in the middle of the basket.

Bait Used

Bait used was mainly fresh fish caught by periodic trawling. On the steel cable setline, sea trout, *Cynoscion viriscens*, croaker, *Micropogon furnieri*, large whiting, *Macrodon anacyclodon*, silverperch, *Larimus breviceps*, catfish, *Arius* sp. and *Bagre* sp., sharks, and other fish were used. Smaller fish, trash fish, and shark refuse when available, was chummed over the line while setting. Small sharks that took the baited hooks often became involuntary bait for bigger sharks and occasionally even these bigger sharks were mutilated by even larger ones. During handlining the smaller whiting and other fishes were used as bait, while trash fish was chummed overboard to attract the sharks to the boat.

Figure 6.—Gutting and dressing the sharks.

Processing On Board

When a shark was landed it was first stunned by sharp blows on the nose with a mallet. The tail was immediately cut off (Fig. 7) in order to bleed the shark while it was still fresh and the heart still beating. This was done to lower the urea level in the body and so reduce the possibility of urea contaminating the meat. When there was no time to process them immediately, they were stored in the shade and kept moist in order not to let the skin dry (Fig. 8). Further processing consisted of cutting off the head and fins and removing the viscera. After this they were very thoroughly washed (Fig. 9), rinsed, and put on ice in the hold. Fins, when large enough, were washed thoroughly with sea water and air dried. The remainder was normally thrown overboard. Many of these remaining parts could still have been used—for example: livers for oil, teeth and jaws for curios, and hides for leather.

Biological Sampling Methods

All sharks caught were identified to species using Bigelow and Schroeder (1948) and Casey (1964) as reference books. When a shark was caught and landed it was measured for total length (tip of snout to tip of upper lobe of caudal fin), classified by sex, and sometimes weighed (after dressing the meat). Beside this information other data such as sexual maturity, number of embryos, state of maturity, stomach contents, etc., were usually noted.

Figure 7.—Cutting off the shark's tail to bleed the shark.

Figure 8.—Sharks stored in the shade for later processing.

EFFORT AND AREA

Effort

The project vessel MV *Calamar* was used during eight cruises for shark exploration work (Table 1). The catch of the first trip was landed in Barbados. During the next three cruises the catch was landed in Port of Spain, Trinidad, partly for marketing purposes and partly for an experi-

Figure 9.—Sharks being washed and rinsed prior to being placed in the ship's hold.

mental food processing project. The catch of the last four cruises was landed mainly in Paramaribo, Surinam for food processing purposes.

Area

The geographic area covered during this exploration was the continental shelf off northeast South America from the Brazil-French Guiana border, northwest to and including the territorial waters of Trinidad (Fig. 10). The area is divided into 30-minute grids according to the longitude and latitude and numbered as shown. This is the area with a good trawl fish potential (Rathjen, Yesaki, and Hsu 1969). It is a regular and muddy continental shelf with many rivers from the South American continent flowing into it.

RESULTS AND COMMENTS

Fishing Operations

Catch by type of gear

The catch figures throughout are presented in pounds of finished dressed shark carcasses unless otherwise specified. This represents about 60 percent of the round weight. The catch rate by gear type is given in Table 2. It gives the catch rates observed for the different types of gear used on all exploratory, experimental, and simulated production fishing.

Table 1.—RV *Calamar* shark exploration cruises.

Cruise no.	Leave Barbados	Return to Barbados	Actual fishing days	Purpose of trip
68-13	3-Dec.-68	14-Dec.-68	8	Explor., experimentation & limited production
69- 1	8-Jan.-69	4-Feb.-69	18	Explor., experimentation & limited production
69- 2	17-Feb.-69	7-Mar.-69	11	Explor., & experimentation
69- 3	17-Mar.-69	1-Apr.-69	9	Explor., & limited production
69-10	9-Sept.-69	24-Sept.-69	31	Explor., & limited production
69-11	10-Nov.-69	17-Dec.-69	23	Explor., & limited production
70- 1	7-Jan.-70	28-Jan.-70	9	Exploration
70- 7	23-June-70	17-July-70	21	Experimentation

The catch per unit of effort was the highest with handlining, but this is biased because handlining (active fishing) at any location ceased soon after it was proved that there were no sharks available. Once the cable setline or any of the remaining methods (passive fishing) was set, however, effort continued without knowing whether or not there were sharks in the immediate vicinity.

The different types of longline were used only during the first three cruises. Thereafter they were abandoned because of low catch rates and because the work involved in longlining is more hazardous to personnel since the possibility of a big shark, or strong current, entangling the longline, is much greater than with the steel cable. Another disadvantage of the drift longline is that it is done in deep water, where bait trawling is not as productive as in shallow water, and is more time consuming.

A steel cable fishing experiment consisting of two periods of fishing overnight compared with the usual one overnight soak was conducted north of Paramaribo lightship, off Surinam, at six different depth intervals. This area was chosen as it proved to be a consistently good productive area during previous cruises and was close to the processing plant in Paramaribo. The results are shown in Table 3.

On an average basis the total of two sets per night provided a catch rate improvement of over 30 percent on an hourly basis and about 50 percent over an entire night's fishing. However, there is obviously more working time involved in making two sets than in a single set; i.e., 2 more hours soaking time plus 1½ hours for retrieving and resetting.

Catch by area

The area covered during shark fishing explorations is virtually the entire continental shelf north of the Guianas of northeastern South America (see Fig. 10). Many rivers flow into the Atlantic in this area. The total area has been arbitrarily divided first by country and second by river outlets per 1° of longitude. The following areas are recognized:

Country	River	Long. and Grid
French Guiana	Oyapock	51° to 52°W (T-39 + U-39)
	Cayenne	52° to 53°W (T-38)
	Iracoube	53° to 54°W (T-37 + S-37)
Surinam	Maroni	54° to 55°W (S-36 + R-36)
	Surinam	55° to 56°W (S-35 + R-35)
	Coppename	56° to 57°W (S-33 + R-34)
Guyane	Coreyyn	57° to 58°W (S-33 + R-33)
	Essequibo	58° to 59°W (R-32 + Q-32)
	Waini	59° to 60°W (Q-31 + R-31)
Venezuela	Orinoco	60° to 62°W (P-30 + O-29)

In Table 4 and Figure 11 the results of the catch per area are given for handlining and steel cable setlines. The best results for handline and steel cable combined were obtained in the Iracoube area of French Guiana. Other good handlining areas were Coppename and Cayenne rivers. The Surinam River area proved to be a consistently good steel cable setline area.

Table 2.—Catch rate by gear type.

Type of gear	No. of sets	No. of hr	Catch in lb	Lb/set	Lb/hr
Handline	—	245½	53,673	—	218.6
Steel cable setline	105	1,212	56,223	535.4	46.4
Bottom longline	13	178	2,042	157.0	11.5
Drift longline	4	47½	1,050	262.5	22.1
Cuban longline	1	4	15	15.0	3.8

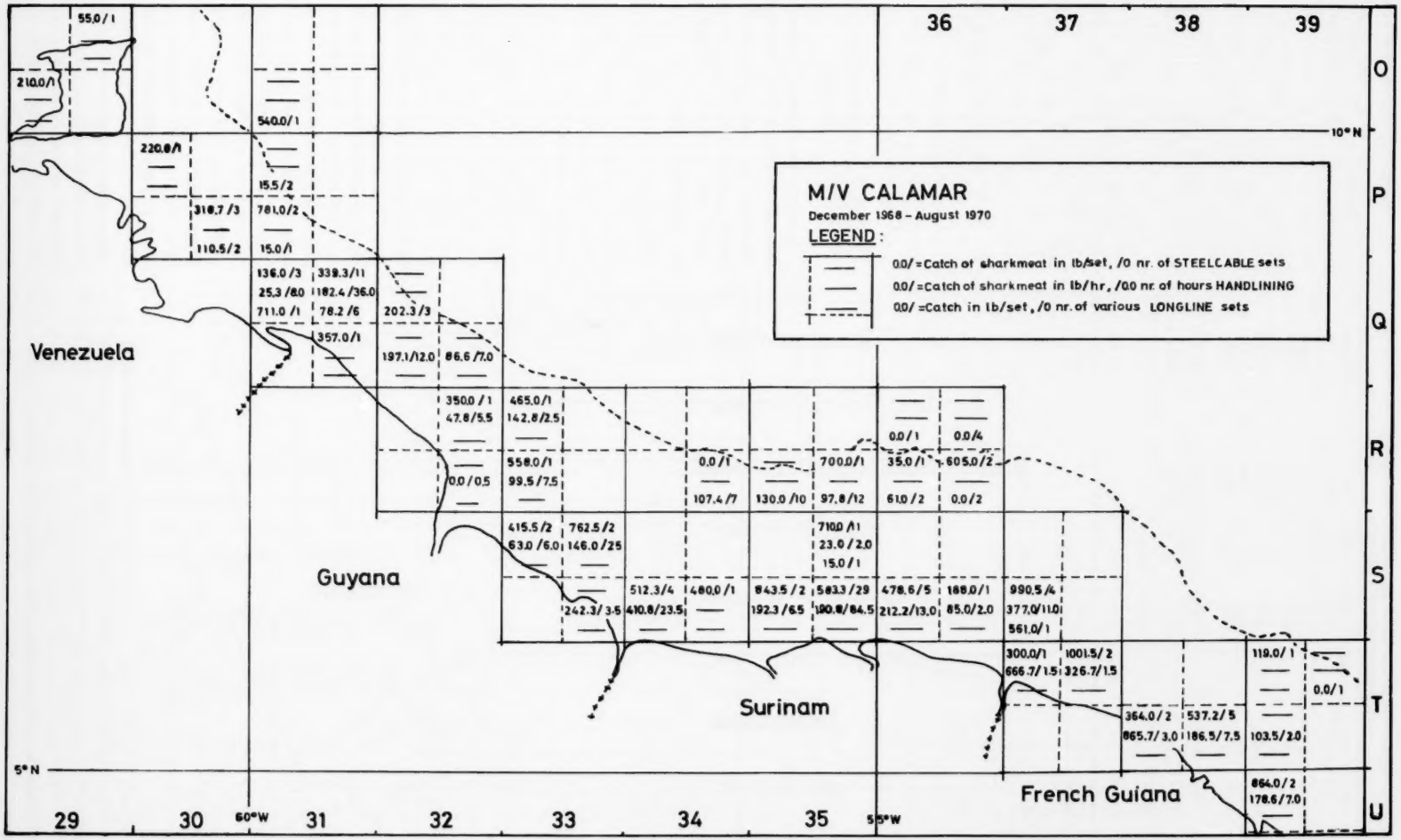


Figure 10.—Area covered during Project shark fishing explorations.

Table 3.—Pounds of dressed shark taken by depth and duration of steel cable set.

Depth (fms)	First half of night (7.8 hr)	Last half of night (7.3 hr)	Total	Overnight (13.0 hr)
5	250	60	310	1,000
10	550	520	1,070	700
15	2,050	470	2,520	250
20	1,000	525	1,525	1,900
25	80	400	480	505
30	750	1,250	2,000	780
Total	4,680 (47 hr)	3,225 (43.5)	7,905 (90.5)	5,135 (78)
Catch lb/hr	99.6	74.1	87.3	65.8
Catch lb/set	780.0	537.5	1,317.5	855.8

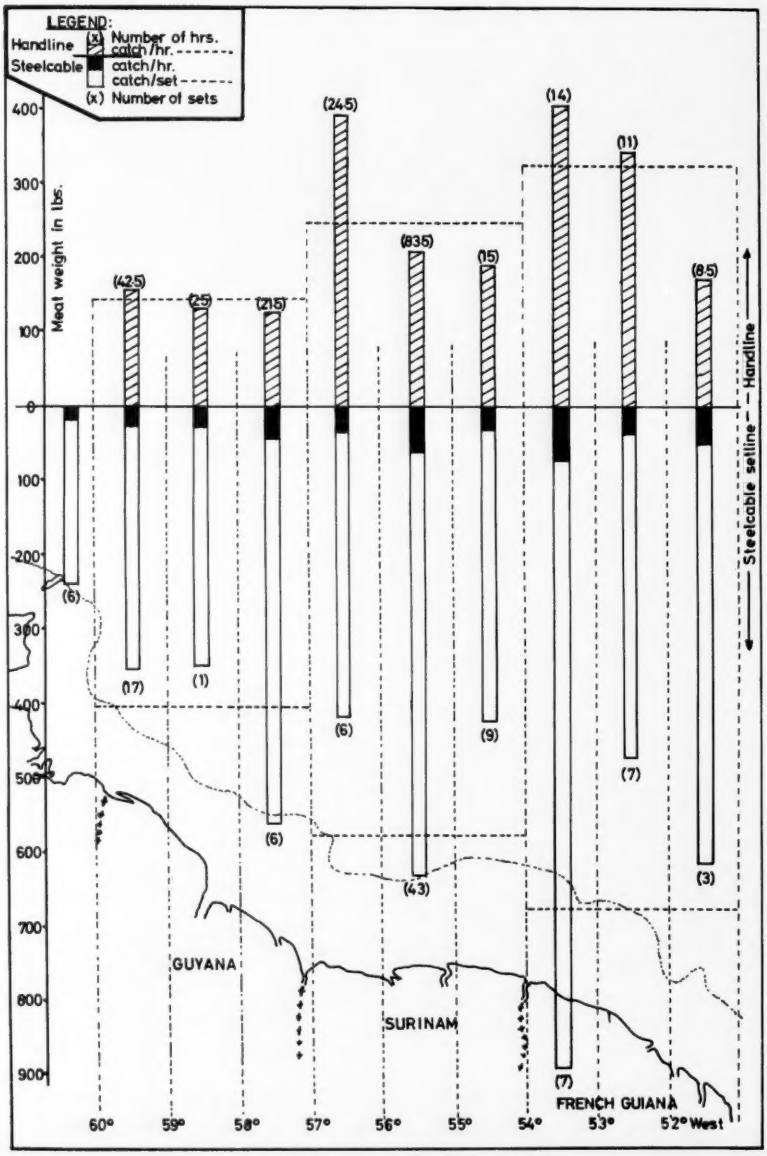


Figure 11.—Handline and steel cable catch of sharks by area.

Catch by depth interval

A breakdown by 5-fathom depth intervals was made to determine the variation in catch per depth. In Figure 12 and Table 5 these data are given. The best depth for combined handlining and steel cable setlining lies between 15 and 20 fathoms.

The most productive trawl area lies between 5 and 30 fathoms (Rathjen et al. 1969), however, and because handlining is so closely linked with trawling for bait and chum, the handline effort in this paper was almost entirely restricted to this depth range. The best depth for handlining alone lies between 10 and 20 fathoms, but for the steel cable setline the situation is a bit different. There the results show the best catches from 5 to 45 fathoms with slight decline at the 10-15 fathom interval.

Catch distribution by month (season)

During the years involved shark fishing was conducted during only 9 months so it is difficult to be definitive on the seasonal distribution of sharks in the area. In Figure 13 and Table 6 the results are shown. The maximum yield per effort occurs in November and December and the minimum in January with a slow increase thereafter. This applies to handlining as well as steel cable setlines.

The shark catch results by season are compared with the seasonal trawl fish catches given in the Project trawl report (Rathjen et al. 1969) in Table 7 and Figure 14. The seasons recognized are winter (December, January, and February), spring (March, April, and May), summer (June, July, and August) and fall (September, October, and November). There is a striking resemblance between the seasonal distribution of steel cable catches and trawl catches which is not reflected in handline catches. This might be caused by a different reaction to the rainy season of the surface (and bottom) water body. Handlining (surface water) is most productive during the dry seasons, i.e., March, April, and September till December (see Fig. 15). The surface water is influenced by an increase in fresh water running off into the sea during the rainy season, causing a decrease in salinity which

could force much marine pelagic life to migrate to more suitable environs and thus reduce the amount of available forage in the inshore shark fishing areas.

Steel cable (bottom water) is best during the rainy season, May till August. The bottom water mass might become enriched with nutrient subsurface water untilted by fresh water masses of the Amazon River (Ryther, Menzel, and Corwin 1967). The main influence of this Amazon water is during July (Gade 1961) at the end of rainy season and slowly diminishes till at the end of the year when the effects are hardly detectable.

Biological Observations

Species caught

During the eight cruises over 4,600 sharks of 25 species were caught. The main yield in numbers as well as meat weight came from four species. The order of importance, according to the numbers, is smalltail shark 44.2 percent, small blacktip shark (which will henceforth be referred to as blacktip shark) 42.9 percent, bull shark 3.8 percent, and tiger shark 3.0 percent. The order of importance by weight is blacktip shark 41.2 percent, tiger shark 15.1 percent, bull shark 14.4 percent, and smalltail shark 11.9 percent. Over 93 percent of the sharks caught belonged to these four species and they contributed over 82 percent of the total meat weight. In Table 8 the catch is given in a species breakdown by sex, method of capture, depth range, and the weight for the most important species.

Smalltail shark. Although the smalltail shark is the most abundant species by number it is only fourth in weight yield. The majority were caught on the handline. These sharks are tough animals which continue to struggle long after they are caught. Dressing them is not easy as they have a well ossified cartilage. Results showing that the smallest smalltail sharks are caught by trawl and steel cable setline and the biggest by handline might perhaps indicate that the young animals live near the bottom and the older ones near the surface. Smalltail sharks caught on steel cable setline became bait and attracted still larger sharks.

Blacktip shark. This was the most important species during the operation and was mainly caught by handline. The blacktip is much easier to process on board than the smalltail shark; it is killed much more easily and dressing is also easier.

Bull shark. These were very often caught with parts of sharks in their stomach, bait, discarded refuse from the previous day's cleaning of the catch, and also sharks that were hooked before. The bull sharks caught

Table 4.—Shark fishing effort, catch, and catch per effort by gear and degree of longitude.

Area	Handline			Steel cable setline			
	No. of hrs.	Catch in lbs.	Catch in lbs./hr.	No. of sets	No. of hrs.	Catch in lbs.	Catch in lbs./set	Catch in lbs./hr.
French Guiana								
Oyapock (51°-52°W)	8.5	1,457	171.4	3	34.5	1,847	615.7	53.5
Cayenne (52°-53°W)	11	3,765	342.3	7	84.5	3,414	487.7	40.4
Iracoube (53°-54°W)	14	5,637	402.6	7	85	6,265	895.0	73.7
Total	33.5	10,859	324.2	17	204	11,526	678.0	56.5
Surinam								
Maroni (54°-55°W)	15	2,919	194.6	9	106.5	3,826	425.1	35.9
Surinam (55°-56°W)	83.5	17,483	209.4	43	439	27,113	630.5	61.8
Coppename (56°-57°W)	24.5	9,717	396.6	6	72.5	2,529	421.5	34.9
Total	123	30,119	244.9	58	618	33,468	577.0	54.2
Guyana								
Corentyne (57°-58°W)	21.5	2,694	125.3	6	73.5	3,379	563.2	46.0
Essequibo (58°-59°W)	25	3,234	129.4	1	12	350	350.0	29.2
Waini (59°-60°W)	42.5	6,767	159.2	17	235	6,059	356.4	25.8
Total	89	12,695	142.6	24	320.5	9,788	407.8	30.4
Venezuela								
Orinoco (60°-61°W)	—	—	—	6	69.5	1,441	240.2	20.7
Total	245.5	53,673	218.6	105	1,212	56,223	535.4	46.4

Table 5.—Shark fishing effort, catch, and catch per effort by gear and depth interval.

Depth (fms.)	Handline			Steel cable setline			
	No. of hrs.	Catch in lbs.	Catch in lbs./hr.	No. of sets	No. of hrs.	Catch in lbs.	Catch in lbs./set	Catch in lbs./hr.
-5	—	—	—	4	42.5	1,393	348.3	32.8
5.5-10	73.0	13,200	180.8	31	329	18,341	591.6	51.1
10.5-15	88.5	23,796	268.9	36	422	14,263	396.2	33.8
15.5-20	28.0	7,544	269.4	13	149	10,942	841.7	73.4
20.5-25	52.5	8,950	170.5	5	52.5	2,817	563.4	53.7
25.5-30	1.5	74	49.3	6	62.5	3,632	605.3	58.1
30.5-35	—	—	—	2	28.5	1,209	604.5	42.4
35.5-40	—	—	—	2	25	1,562	731.0	62.5
40.5-45	—	—	—	2	23.5	1,219	609.5	51.9
45.5-50	—	—	—	1	11	110	110.0	10.0
50.5-55	—	—	—	—	—	—	—	—
55.5-60	—	—	—	2	23.5	735	317.5	31.3
60+	2.0	109	54.5	1	13	0	0.0	0.0
Total	245.5	53,673	218.6	105	1,182	56,223	535.4	46.4

Table 6.—Shark fishing effort, catch, and catch per effort by gear and month.

Catch per month	Handline			Steel cable setline			
	No. of hrs.	Catch in lbs.	Catch in lbs./hr.	No. of sta.	No. of hrs.	Catch in lbs.	Catch in lbs./set
January	82.5	11,100	134.5	21	263.5	7,547	359.4
February	17	4,104	241.2	8	98	3,556	444.5
March	37	9,838	265.9	9	108	3,631	403.4
July	26.5	6,547	247.1	19	174.5	13,203	694.9
August	13.5	2,459	182.1	6	58.5	2,451	408.5
September	22	4,320	196.4	11	124.5	7,083	643.9
October	6	711	118.5	8	94.5	4,044	505.5
November	15.5	5,064	326.7	10	117	7,051	705.1
December	25.5	9,530	373.7	13	173.5	7,657	693.2
Total	245.5	53,673	218.6	105	1,212	56,223	535.4

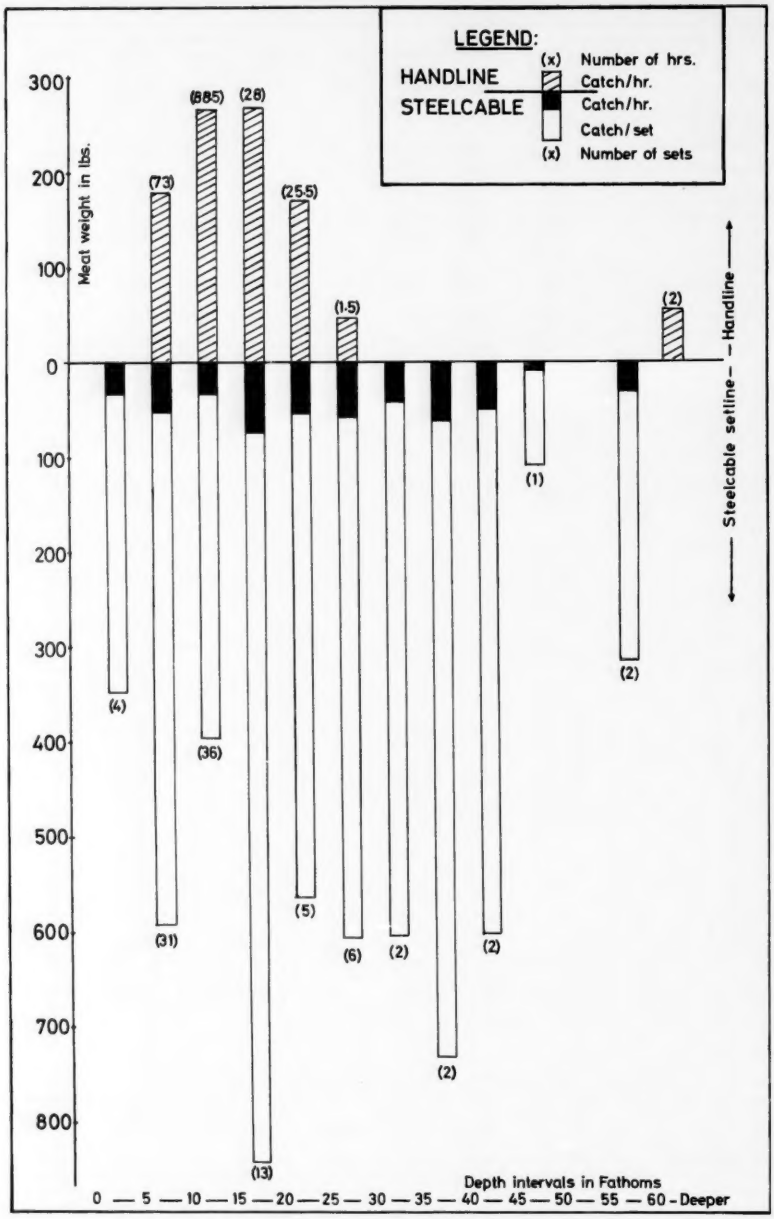


Figure 12.—Handline and steel cable catch of sharks by depth interval.

on setlines, including even the larger ones, were sometimes badly mutilated by other sharks.

Tiger shark. These were often still alive when caught on the steel cable setline; the contrary held true for the bull sharks. They often gave a heavy struggle before being decked. These sharks are easy to dress as they have a very soft cartilage. Their stomachs contain a large variety of items such as turtle, all kinds of fishes, birds, and sharks. These sharks are true scavengers.

Other sharks. The meat of nearly all the sharks caught was used for further processing on land except for the nurse shark whose meat deteriorated rapidly after being caught and was discarded.

Table 7.—Seasonal catch rates for shark handlining and steel cable setlines and bottom fish trawling.

Season	Handline Catch lb/hr	Handline Rank no.	Steel cable Catch lb/hr	Steel cable Rank no.	Total trawl by *Calamar* Catch lb/hr	Total trawl by *Calamar* Rank no.
Winter	198.7	(4)	35.1	(3)	665.7	(3)
Spring	265.9	(1)	33.6	(4)	608.0	(4)
Summer	225.3	(3)	67.2	(1)	986.5	(1)
Fall	232.1	(2)	54.1	(2)	769.7	(2)

Length frequency

Total length was measured on most of the sharks caught. As the total number of the majority of species caught was very small, only length frequency curves for the four major species were prepared (see Figs. 16, 17). These curves show that the females of the three carcharhinid species (smalltail, blacktip, and bull shark) develop to a larger size than the males (Table 9).

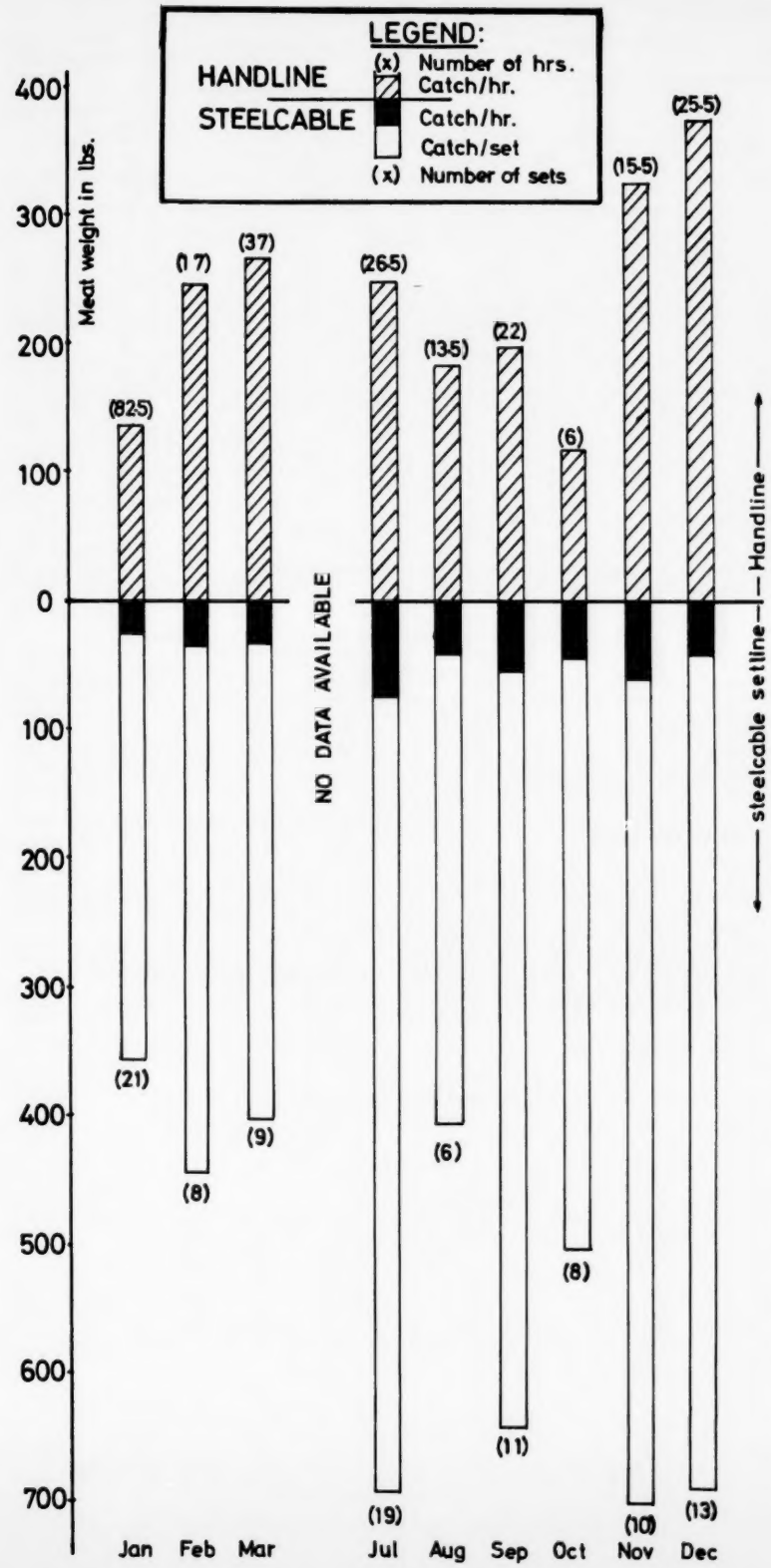
The tiger sharks have a much greater length range, but the number caught was relatively few, so the sex difference in average length is not considered significant.

From the two species most frequently caught by steel cable and handline (smalltail shark and blacktip shark), we can see from Table 10 that the smalltail shark caught by steel cable is smaller than those caught by handline. This is the reverse of the blacktip shark (Table 10).

Length/weight correlation

The total length of each weighed shark (in centimeters) was compared with its weight (in kilograms) to find the correlation between the two values (Table 11). The length/weight correlation is of importance as it is easy to measure the length of a shark, but not so easy to accurately weigh him on a ship at sea. In Figure 18 the length/weight regression lines of the four main species are shown for the relation between dressed weight and length. The blacktip shark is the only species where enough data are available to compare dressed weight and round weight to length. The weight of dressed blacktip sharks is approximately 60 percent of the round weight.

Figure 13.—Handline and steel cable catch of sharks by month.



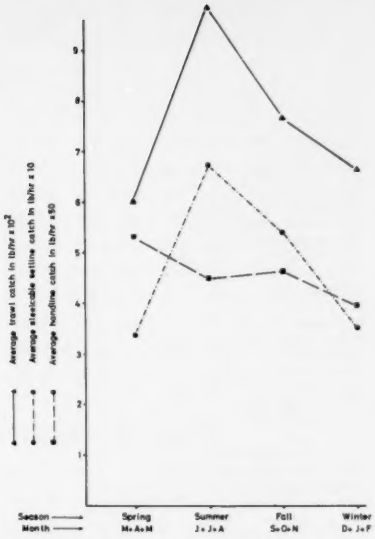


Figure 14.—Comparison of steel cable setline and handline catches with trawl catches per season as given in Rathjen et al. 1969.

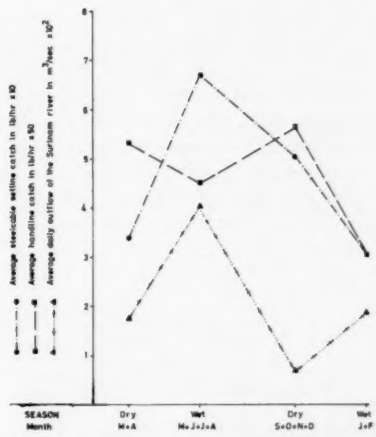


Figure 15.—Comparison of steel cable setline and handline catches with the average daily outflow of the Surinam River per rainy season.

SUMMARY

Shark fishing explorations were carried out by the UNDP/FAO Caribbean Fishery Development Project with the MV *Calamar* from December 1969 until August 1970.

Different fishing techniques were used, but emphasis was put on handlining and bottom (steel cable) setlining. The area covered is roughly the continental shelf of South America off the Guianas.

Over 4,600 sharks were caught of

Table 8.—Shark catch by species, number, sex, type of gear and depth range.

Common name	Total no. (includes animals not sexed)	Sex composition No. of females	No. of males	Gear type Handline	Steel cable	Other*	Depth range	Meat wt. of 4 main species in lbs.
Shortfin mako	2	0	2	0	0	2 (a)	350	
Bigeye thresher	1	0	1	0	0	1 (a)	80	
Nurse shark	2	0	2	0	2	0	19	
Smooth dogfish	7+	4	2	0	0	7+(a+b+c)	5-180	
Tiger shark	139	67	68	0	136	3 (d)	5- 60	17,034
Blue shark	2	0	2	0	0	2 (a)	80-360	
Sharpnose shark	5	4	1	2	3	0	9- 16	
Finetooth shark	11	5	6	8	3	0	6- 12	
Lemon shark	20	7	13	0	20	0	5- 15	
Night shark	5	3	1	0	0	5 (a+b)	80-190	
Bignose shark	3	2	0	0	0	3 (b)	140-190	
Silky shark	78	34	42	19	57	2 (a+b)	15-186	
Bull shark	174	55	114	2	164	8 (d)	5- 35	16,315
Blacktip shark	1,983	829	1,108	1,846	132	5 (d)	4- 34	46,603
Spinner shark	3	2	1	2	1	0	15- 26	
Sandbar shark	30	5	25	0	30	0	19- 60	
Dusky shark	27	11	16	0	26	1 (d)	6- 60	
Bladenose shark	1	0	1	0	0	1 (c)	8.5	
Smalltail shark	2,040	1,129	710	1,577	408	55 (a+b+c+e)	4- 40	13,528
Reef shark	1	0	1	0	1	0	60	
Smalleye hammerhead	31	18	12	0	25	6 (c)	5.5- 15	
Scalloped hammerhead	17	7	10	0	16	1 (a)	8- 45	
Bonnet head	12+	5	4	0	0	12+(c)	9- 15	
Great hammerhead	18	11	6	0	18	0	5.5- 35	
Cuban dogfish	1	1	8	0	0	1 (b)	120-180	
Total	4,613+	—	—	3,456	1,042	115+		

*A = drifting longline, b = deepwater bottom longline, c = trawl, d = shallow water bottom longline, e = Cuban longline.

25 species yielding over 110,000 pounds of dressed meat. Nearly half of this was caught during 245 hours of handlining with 1-8 lines and about the same amount was caught with 105 sets or 1,212 hours of steel cable setlines with 100-175 hooks. The results were compared for depth, area, and month. Length frequency and length/weight correlation was also established for the four principal species.

Table 9.—Difference in average length between males and females.

Species	Females No.	Females Aver. length (cm)	Males No.	Males Aver. length (cm)
Smalltail Shark	910	94.52	599	90.39 (95.6% of females)
Blacktip shark	699	139.99	974	134.20 (95.9% of females)
Bull shark	52	226.44	109	211.86 (93.6% of females)
Tiger shark	67	247.63	65	249.38 (100.7% of females)

CONCLUSIONS

As a result of the explorations the following conclusions are drawn. When the whole area off the coast of the Guianas is considered, an average of 3,000 pounds (1,360 kg) of dressed shark meat was taken per 24 hours of fishing, i.e., 1,000 pounds with two steelcable sets during the night and 2,000 pounds with handlining during the day alternating with required trawl hauls.

Sharks are most abundant in the 15-20 fathom depth interval.

Sharks are most abundant in the

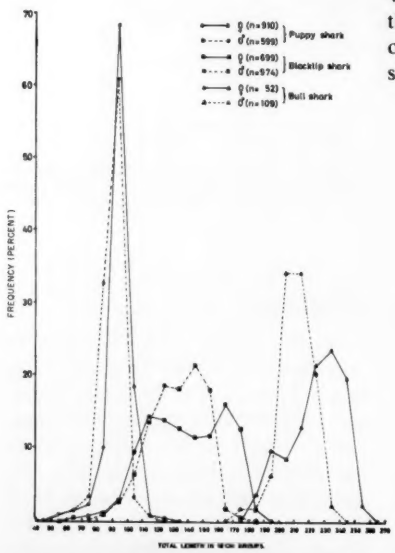


Figure 16.—Length frequencies observed in the catch of both sexes of three shark species.

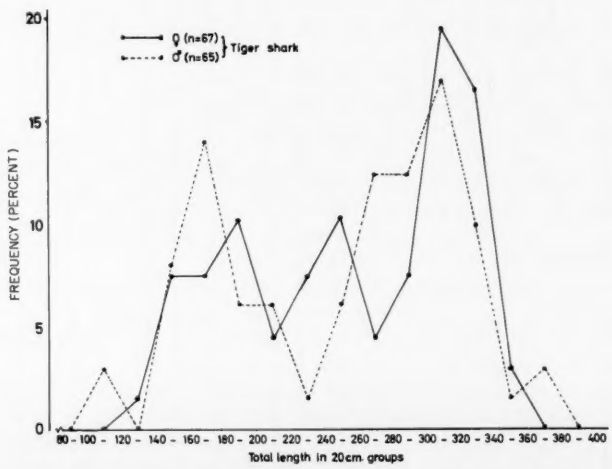


Table 10.—Difference in average length between sharks caught by handline and steel cable.

Species	Sex	No.	Aver. length Steel cable	No.	Aver. length Handline
Smalltail shark	female	269	92.73	644	95.55
	male	194	89.48	406	91.10
Blacktip shark	female	44	150.07	650	139.36
	male	74	143.76	880	136.23

Table 11.—Length/weight relationship of the four principal shark species taken.

Species	Number	Aver. round wt.	Aver. dressed wt.	Aver. total length (live)	Line of regression	Correlation coefficient
Smalltail shark	120	—	3.1 kg	94.6 cm	.0117X-.6030	0.87
Blacktip shark	238	18.3 kg	—	133.3 cm	.0100X-.0586	0.97
	129	—	12.5 kg	138.2 cm	.0095X-.2990	0.99
Bull shark	125	—	42.8 kg	216.5 cm	.0054X + .4421	0.98
Tiger shark	124	—	55.9 kg	252.5 cm	.0062X-.0056	0.98

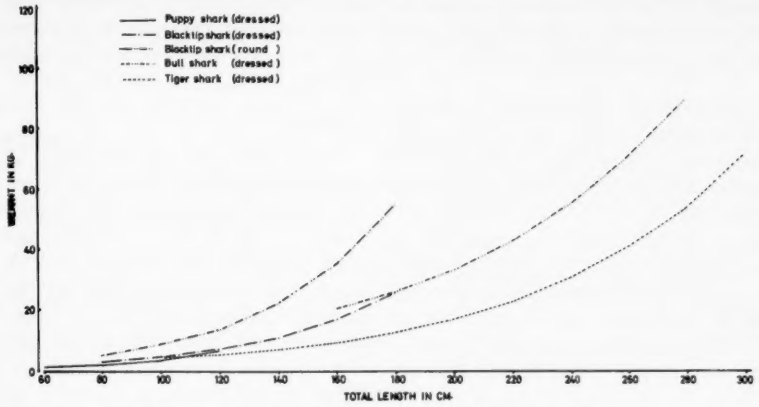


Figure 18.—Length/weight curves of four principal species of shark taken.

Iracoube River (long.53°-54°W) and Coppename River (long.56°-57°W) areas.

Sharks are apparently most abundant in the Guianas during November and December.

The most common species taken were small blacktip shark, smalltail shark, bull shark, and tiger shark.

Handlining was found to be the most effective way of fishing in terms of yield per hour fished, providing chum was also used.

Over 40 percent of round weight of sharks is lost during initial dressing on board the vessel. Of this some parts (fins, teeth, jaws, livers, and hides) have potential value.

Whenever shark fishing is being considered on a commercial basis in the areas indicated, it is suggested that fishing be done in cooperation with shrimp trawlers, if possible, as they discard large quantities of trash fish which attract sharks. This arrangement would greatly reduce the necessity or frequency of the shark fishing vessel doing its own trawling for bait and chum.

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MFR PAPER 1090

Minor Miscellaneous Exploratory/Experimental Fishing Activities in the Caribbean and Adjacent Waters

ROBERT S. WOLF

ABSTRACT—The Caribbean Fishery Development Project conducted nearly five years of experimental, exploratory, demonstration, and simulated production fishing activities within its sphere of operations during Project Phases I and II. This paper describes work of lesser importance whose results were not significant enough to warrant separate presentation. It is concerned mainly with reporting the results of the exploration of small resources or the infrequent application of certain fishing techniques to larger resources.

During deepwater bottom longlining explorations, an average catch rate of 0.5 pound per hook was observed. A maximum catch rate of 1.0 pound per hook was observed in 105-195 fathoms of water 100 miles north of Paramaribo, Surinam. The catch composition was 80 percent tilefish, 16 percent grouper, and 4 percent miscellaneous.

Bait trawling operations, as an adjunct to shark fishing, provided an opportunity to test the effectiveness of a small, 38 × 44 foot, specially made trawl with that of the trawl used during Calamar's exploratory trawling cruises. The small net caught a lesser proportion of marketable food fish, which suggests that the larger, higher opening nets will catch a greater proportion of off-bottom seatrout and croaker than a small bottom-hugging net.

Pelagic fish attraction experiments confirmed that drifting objects will attract an aggregate of pelagic fishes that will vary, but generally increase in size and species complexity with time. A small concentration of scallops was located in 40 fathoms of water, 10 miles northwest of Los Testigos Islands, Venezuela. Later attempts to delineate the extent of the concentration were not successful. Project fishing operations with gill nets covered a wide scope of locale and timing, although total effort was small. Only during night drift operations and daytime anchored bottom netting off Trinidad was any success achieved.

Most of the exploratory and/or experimental fisheries operations of the Caribbean Fishery Development Project were of sufficient magnitude to warrant individual reports. This report has been prepared to summarize all of the miscellaneous exploration accomplished on minor resources and miscellaneous experimental fishing efforts accomplished by the Project. Included are experimental and exploratory deepwater bottom longlining, incidental trawling (consisting mostly of shark bait trawling), experimental attraction of surface pelagic species, scalloping, and gill netting accomplished by Project vessels: *Alcyon*, *Calamar*, and *Fregata*. None of the subjects covered is considered to possess more than slight commercial potential, but is presented herein as a portion of the total exploratory/experimental work accomplished and for general information on overall fishing interest in the Caribbean.

DEEPWATER BOTTOM LONGLINING

During October 1967 and January 1968, the U.S. National Marine Fisheries Service (then, Bureau of Commercial Fisheries) fishery research vessel, *Oregon II*, conducted deepwater longlining operations between

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30 and 300 fathoms around the periphery of the Gulf of Mexico (Nelson and Carpenter 1968). Although the catches were concluded to be generally insufficient to support any commercial effort, a significant showing of tilefish (*Lopholatilus chamaeleonticeps*) was observed. Off the north Gulf Coast catches approached ¼ pound per hook between 163 and 187 fathoms off Texas and Louisiana, catches in excess of ¼ pound per hook were made between 138 and 162 fathoms, and approaching ½ pound per hook between 188 and 212 fathoms.

Tilefish

The tilefish has been the object of fisheries, but mostly in the past. A few are caught incidentally by snapper boats and landed in U.S. Gulf Coast ports. Bigelow and Schroeder (1953) report an extensive fishery off the central Atlantic coast of the United States in the latter half of the last century. This fishery was greatly curtailed by an extensive mortality of tilefish near the end of the last century and the fishery has never really recovered.

A depth/temperature/bottom-type regime similar to that off the eastern U.S. was found to exist on the edge of the continental shelf north of the Guianas. Consequently, during cruise 68-13, *Calamar* made two experimental bottom longline sets of 75 hooks each, between 100 and 200 fathoms 60 miles east-northeast of Waini Point, Guyana. Five tilefish were caught, which proved their existence in the project region and stimulated additional exploratory activity.

Area and Effort

Subsequent to the first deepwater bottom longline sets mentioned above, *Calamar* completed 43 additional sets either on a specific cruise (69-7) or as an adjunct to experimental/exploratory shark fishing cruises (69-10, 70-8) (Table 1). Sets were made off the edge of the continental shelf from Guyana to French Guiana in waters from 100 to 225+ fathoms deep (Fig. 1).

Gear

The standard fishing gear utilized during deepwater longline explorations is diagrammed in Figure 2. It consisted of a 1,000 foot ¼ inch tarred nylon mainline (tuna longline) anchored with expendable weights at each end. Each end was also buoyed with a flag marker. Branch lines were clipped on at about 10-foot intervals. Each branch line consisted of a No. 8 or 9 tuna circle hook (A) fastened to a 1 foot wire leader (B), attached to 18 inches of 190-pound test nylon monofilament (C), then a No. 8/0 barrel swivel (D) and snap on attachment (E), which could be placed anywhere on the main line.

Hooks were baited with squid, shark meat, or seatrout.

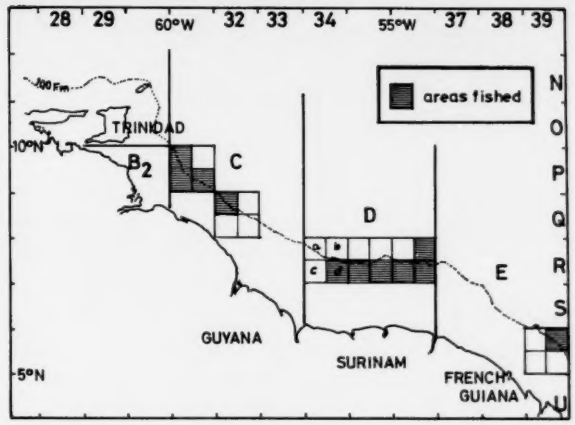

Figure 1.—Northeastern South American coastal shelf showing grids (areas) where deepwater setlining occurred.

Method

The gear was set from the stern of the moving vessel. First a flag buoy was thrown overside, which dragged after it a buoy line longer than the expected water depth. The anchor, attached to the end of the buoy line and to one end of the main line, was then thrown over. As the main line paid out, prebaited branch lines were clipped on at approximately 10-foot intervals until 100 hooks had been attached. The second anchor was fastened to the mainline, then thrown out along with the second buoy line and buoy.

The gear was soaked from 1 to 3 hours after which it was recovered over the starboard waist of the vessel

Table 1.—Record of deepwater longline sets.
(Fish catches given in numbers - pounds.)

Date	Cruise	Station	Lat. (N)	Long. (W)	Grid	Depth range	Number of hooks (recovered)	Tilefish catch	Grouper catch	Other fish total[1]	Total catch
9 Dec. 68	68-13	639	8°51′	58°51′	Q-32a	105-120	75	3 - 30	2- 50	1- 17	6- 97
10 Dec. 68	68-13	641	8°51′	58°49′	Q-32a	160-200	30	2 - 66	—	—	2- 66
24 June 69	69-7	769	9°34′	59°38′	P-31a	135-150	105	13 - 94	—	—	13- 94
24 June 69	69-7	770	9°33′	59°38′	P-31a	125-138	105	3 - 31	1- 9	1- 6	5- 46
26 June 69	69-7	771	9°06′	59°12′	P-31d	138-150	187	3 - 26	3- 80	2- 20	8- 126
26 June 69	69-7	772	9°23′	59°34′	P-31c	120-145	44	—	1- 7	—	1- 7
18 Sept. 69	69-10	815	7°25′	55°32′	R-35c	150-155	100	—	—	6- 70	6- 70
26 Sept. 69	69-10	825	7°22′	56°12′	R-34d	138-159	100	4 - 75	—	1- 20	5- 95
26 Sept. 69	69-10	826	7°20′	56°01′	R-34d	141-162	100	1 - 21	—	—	1- 21
1 Oct. 69	69-10	831	7°28′	54°29′	R-36d	123-125	100	—	—	—	—
1 Oct. 69	69-10	832	7°32′	54°28′	R-36b	150-153	100	—	—	—	—
1 Oct. 69	69-10	833	7°35′	54°28′	R-36b	170-183	100	—	—	—	—
2 Oct. 69	69-10	835	7°37′	54°23′	R-36b	195-200	100	—	—	—	—
2 Oct. 69	69-10	836	7°34′	54°40′	R-36b	192-194	100	—	—	—	—
3 Oct. 69	69-10	838	7°27′	55°05′	R-35d	195-225	100	5 - 95	—	—	5- 95
3 Oct. 69	69-10	839	7°25′	55°09′	R-35d	126-195	100	8 - 120	1- 25	—	9- 145
3 Oct. 69	69-10	840	7°25′	55°10′	R-35d	127-141	100	5 - 67	—	—	5- 67
7 Oct. 69	69-10	843	7°29′	54°08′	R-36d	148-150	99	—	—	—	—
7 Oct. 69	69-10	844	7°32′	54°06′	R-36b	172-174	99	—	—	—	—
8 Oct. 69	69-10	846	7°28′	54°57′	R-36c	180-183	200	1 - 10	—	—	1- 10
9 Oct. 69	69-10	847	7°25′	54°59′	R-36c	156-165	100	3 - 81	1- 31	—	4- 112
9 Oct. 69	69-10	848	7°25′	55°02′	R-35d	156-195	100	8 - 90	—	—	8- 90
9 Oct. 69	69-10	849	7°28′	55°03′	R-35d	140-165	100	10 - 164	2- 31	—	12- 195
9 Oct. 69	69-10	850	7°28′	55°05′	R-35d	140-160	100	1 - 13	1- 10	—	2- 23
15 Oct. 69	69-10	862	7°21′	55°10′	R-35d	156-186	98	3 - 67	—	—	3- 67
15 Oct. 69	69-10	863	7°21′	55°12′	R-35d	120-162	98	9 - 140	—	—	9- 140
15 Oct. 69	69-10	864	7°20′	55°14′	R-35d	105-159	98	8 - 101	—	—	8- 101
15 Oct. 69	69-10	865	7°20′	55°15′	R-35d	120-180	98	3 - 54	—	—	3- 54
16 Oct. 69	69-10	866	7°22′	55°17′	R-35d	105-186	98	5 - 95	—	—	5- 95
16 Oct. 69	69-10	867	7°19′	55°17′	R-35d	107-135	98	9 - 101	—	—	9- 101
18 Nov. 69	69-10	885	5°50′	51°25′	T-39b	150-225	200	—	—	—	—
7 Aug. 70	70- 7	1089	7°18′	55°48′	R-35c	137-195	300	26 - 246	3- 66	—	29- 312
7 Aug. 70	70- 7	1090	7°17′	55°48′	R-35c	145-168	90	6 - 80	2- 40	—	8- 120
8 Aug. 70	70- 7	1091	7°18′	55°51′	R-35c	124-165	300	6 - 70	—	—	6- 70
8 Aug. 70	70- 7	1092	7°17′	55°52′	R-35c	119-183	236	8 - 110	3- 56	—	11- 166
8 Aug. 70	70- 7	1093	7°17′	55°54′	R-35d	90-174	280	6 - 49	8- 89	—	14- 138
9 Aug. 70	70- 7	1094	7°18′	55°52′	R-35c	120-180	314	15 - 209	5- 82	—	20- 291
9 Aug. 70	70- 7	1095	7°18′	55°53′	R-35c	180-215	305	2 - 22	—	—	2- 22
9 Aug. 70	70- 7	1096	7°18′	55°39′	R-35c	115-170	293	1 - 13	—	—	1- 13
10 Aug. 70	70- 7	1097	7°18′	55°56′	R-35c	144-165	301	3 - 18	—	—	3- 18
10 Aug. 70	70- 7	1098	7°21′	56°02′	R-34d	126-180	296	18 - 224	—	—	18- 224
10 Aug. 70	70- 7	1099	7°21′	56°02′	R-34d	159-188	298	14 - 112	—	2- 20	16- 132
11 Aug. 70	70- 7	1100	7°21′	56°02′	R-34d	147-192	299	2 - 29	—	—	2- 29
11 Aug. 70	70- 7	1101	7°21′	56°03′	R-34d	147-186	294	6 - 75	—	—	6- 75
11 Aug. 70	70- 7	1102	7°20′	56°03′	R-34d	117-170	280	4 - 48	—	—	4- 48
						Totals	7,118	224 -2,848	33-576	13-155	270-3,575

[1]Mostly sharks.

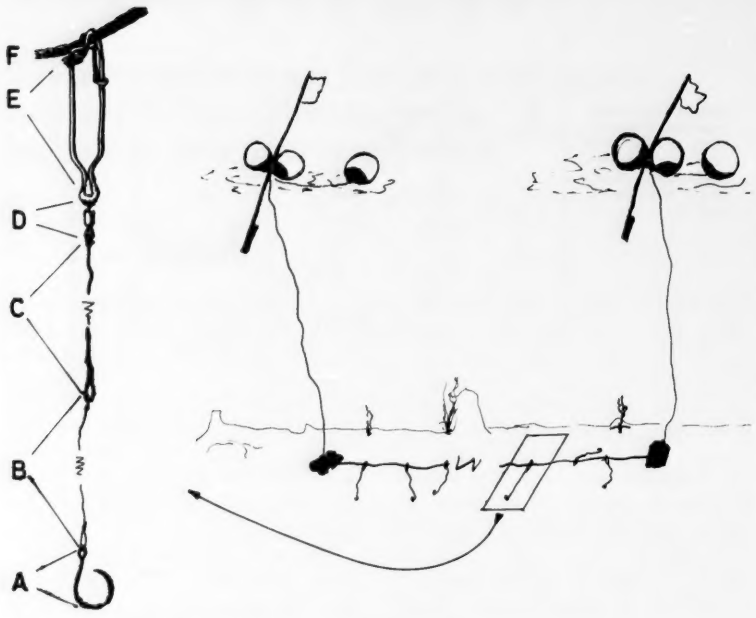

Figure 2.—Deepwater bottom longline with details of branch lines.

using the main winch to haul, while steaming upwind to the gear. The buoy lines were coiled by hand and the main lines run on a drum of the trawl winch. Branch lines were detached as they came over the rail.

Results

The results of each deepwater longline set are given in Table 1. A total of 224 tilefish weighing 2,846 pounds was taken during the exploratory period. Added to this were 33 grouper (mostly yellow edge, *Epinephelus* sp.) weighing 576 pounds, plus 13 miscellaneous (mostly sharks) at 153 pounds, making a grand total of 270 fish, weighing 3,575 pounds taken during the total 45 sets.

In Table 2, the catch is broken down by areal grid. The appropriate grids are shown in Figure 1. The highest catch of tilefish was observed in Grid R 35 d, while Grid R 35 c had the greatest total poundage of fish.

When the catch per set of tilefish was plotted against the number of hooks per set and the number of hours per set, both showed some degree of positive correlation. The peaks appeared at about 300 hooks/set and 3.5 hours soaking.

The commercial potential for deepwater longlining in this general area appears to be only marginal. In area R 35 d (between 100 and 200 fathoms, north of Surinam) the best catch rates were observed. These only approached one per hook. It would therefore require at least three sets of 100 hooks, soaking for over 3 hours per set to even expect commercial quantities. There are no data on population density, but it is concluded to be only slight to moderate because of the precipitous nature of the continental slope at the depths where tilefish, the principal species, is found.

This type of fishing could be done to supplement snapper fishing on the shelf edge and is advised for this only.

INCIDENTAL TRAWLING

The trawlfish resource off the northeastern coast of South America was found to be the largest fishery resource inside the Project region. During 20 cruises in 1967 and 1968, *Calamar* expended 700.0 hours on trawling effort to capture over 490,000 pounds of fish (Rathjen, Yesaki, and Hsu 1969). Upon completion of this work, eight cruises were devoted to exploratory and experimental shark fishing in the shallow (shore to 100-fathom curve) region depicted in Figure 1. A necessary addition to shark fishing was the procuring of bait. This required trawl fishing and to some extent represented a follow-up to the large scale exploratory trawling operations already completed. This report is based on the results of all shark bait trawling and some minor experimental shrimp trawling efforts conducted off Jamaica during *Alcyon* cruise 71-4a.

Gear and Methods

The shark bait trawl was designed and constructed by the Project. It is a modified shrimp net 43 feet long, having 2 inch stretched mesh throughout, excepting for a 1½-inch cod end. The 38-foot headrope was normally fitted with 5-7 can floats while the 44-foot footrope was chain-weighted. The net wings were fastened to the 3 × 6 foot 250 pound chain-bridled doors with 3 foot straps. The doors were fastened to the ends of a 20-fathom ½-inch wire towing bridle, which was in turn shackled to the ½-inch single trawl wire.

The net was set from the forward gallows on the starboard side, while the vessel steamed at a moderate speed in a wide circle to starboard. A depth to trawl wire scope rate of 3 or 4 to 1 was used in waters 10 to 30 fathoms deep. Tow length was usually ½ to 2 hours, which was determined by the immediate need for bait and

Table 2.—Deepwater bottom longline catch by statistical grid.
(Fish catches given in numbers - pounds.)

Grid	No. of sets	Total no. hooks	Total no. hrs.	Tilefish catch	Grouper catch	Other catch	Total catch	Catch/ hook	Catch/ hr.
P-31a	2	210	5.1	16- 125	1- 9	1- 6	18- 140	0.66	27.4
P-31c	1	44	2.5	—	1- 7	—	1- 7	0.16	2.8
P-31d	1	187	5.2	3- 26	3- 80	2- 20	8- 126	0.67	24.2
Q-32a	2	105	4.0	5- 96	2- 50	1- 17	8- 163	1.55	40.8
R-34d	7	1,667	21.2	49- 584	—	3- 40	52- 624	0.37	29.4
R-35c	10	2,519	29.4	73- 817	21-333	6- 70	100-1,220	0.48	41.5
R-35d	12	1,188	30.8	74-1,107	4- 66	—	78-1,173	0.99	38.1
R-36b	5	499	11.8	—	—	—	—	—	—
R-36c	2	300	7.9	4- 91	1- 31	—	5- 122	0.41	15.4
R-36d	2	199	5.2	—	—	—	—	—	—
T-39b	1	200	2.3	—	—	—	—	—	—
Totals	45	7,118	125.4	224-2,846	33-576	13-153	270-3,575	—	—

whether immediately previous tows in the same area had yielded good results.

The net used for shrimp trawling in Jamaica is the same as that used for trawling lobsters (Chislett and Yesaki 1971) except for the addition of a ¼-inch mesh cod end liner.

Results

One hundred and forty-one shark bait tows, occupying over 239 hours, yielded a total of 50,315 pounds. Of this total, 17,924 pounds (35.6 percent) were marketable fish, 23,165 pounds (46.1 percent) were industrial fish (catfish, sharks, skates, and rays) and 9,226 pounds (18.3 percent) were invertebrates, including shrimp. Of the marketable fish caught, 5,917 pounds (33.0 percent) were seatrout, 3,340 pounds (18.7 percent) were croaker, 4,395 pounds (24.5 percent) were whiting, and the remainder (23.8 percent) were mixed fish. Shrimp made up 5.6 percent of the invertebrate catch.

Although shark bait was trawled from Trinidad to French Guiana, emphasis was placed on the areas off the Corontyne and Surinam Rivers off Surinam, and off Waini Point, Guyana.

Three 15-minute drags were made in the Portland Bight area off the south coast of Jamaica on *Alcyon* cruise 71-4. No shrimp were caught, but a few invertebrates and small sciaenid fishes were taken. A fourth drag was attempted off the mouth of Black River, but the net was nearly destroyed and shrimp trawling efforts were terminated without tangible result.

Discussion

Even though shark bait trawling was conducted in the same general areas as *Calamar* exploratory food fish trawling, the catch proportions were dissimilar (Table 3). The reasons for this are felt to be due to the difference in fishing gear (a large high opening light trawl for food fish versus a small size bottomhugging net for shark bait) and the emphasis on trawling in localities displaying a high proportion of seatrout during simulated production food fish trawling.

The large (70 × 83 foot and 60 × 80 foot) high opening bottom trawls are designed to be the most efficient at catching fish living just off the bottom. Since it is a modified shrimp trawl, the shark bait trawl tends to fish closer to the bottom. The shark bait net caught a lesser proportion of marketable fish (principally seatrout and croaker), but a greater proportion of industrial fish and invertebrates, including shrimp. It is apparent then that anyone intending to use modified shrimp nets as production fishing gear for marketable fish species, might expect to obtain only about one-fourth to one-third as much seatrout and about half as much croaker as he might catch by using the larger, lighter high opening trawl used for food fish explorations.

FISH ATTRACTION

At the outset of this project, the Caribbean was felt to hold a large resource of surface and subsurface pelagic fish species. After a number of cruises including surface longlining, live bait, pole-and-line fishing, trolling, and some surface gill netting had taken place with only limited success, it was decided that the resource was perhaps not as extensive as first hoped and what fish did exist tended to be relatively scattered, making the conventional methods of fishing less productive.

It is known that certain surface pelagic fish species are attracted to and held around floating and semi-submerged objects, both drifting and anchored in place (Hunter and Mitchell 1967, 1968; Inoue, et al. 1968; Kojima 1960 a, b; Klima and Wickham 1971). This fact has been utilized for many years in the West Indies where free-drifting items are avidly sought for the schools of dolphin (*Coryphaena* sp.), wahoo (*Acanthocybium solanderi*), etc., which are often in their vicinity. It appears that an artificial means of concentrating surface pelagic species could provide for increased catches in the Caribbean Fishery Development Project region.

Anchored Objects

The Project, on several occasions, anchored structures in attempts to assess their attractivity. A list of anchored structures is given in Table 4.

In total, 12 anchored rafts were placed in the eastern Caribbean for varying periods during 4 years. None of these were considered to have shown a significant positive result. Most were lost for one reason or another after only a short period of anchorage. Some of these losses were the result of interference from local fishermen.

Drift Fishing

In February 1969, the U.S. research vessel *Discoverer* attracted large quantities of dolphin fish while drifting for 17 days, as a portion of the Atlantic Tradewind Expedition (Potthoff 1969). The attraction was an indirect one, as the dolphin were attracted to forage

Table 3.—Comparison of *Calamar* exploratory food fish trawling and *Calamar* shark bait trawling by area.

Zone[1]	Orinoco (B2)		Guyana (C)		Surinam (D)		French Guiana (E)		Totals	
	Food fish explorations	Shark bait	Food fish explorations	Shark bait	Food fish explorations	Shark bait	Food fish explorations	Shark bait	Food fish explorations	Shark bait
No. of stations	6	3	46	41	236	77	30	20	318	141
Time (Hrs.)	9.8	5.0	67.1	56.4	562.3	141.1	41.7	36.6	680.9	239.1
Total catch (percent)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total fish catch/lb.	11.3	88.8	92.2	63.8	97.8	86.8	80.5	90.4	95.4	81.7
Marketable fish/lb.	10.1	50.7	75.3	35.4	68.6	35.0	52.6	38.2	67.8	35.6
Trout/lb.	7.2	2.2	8.9	9.7	44.1	14.3	15.2	2.0	39.7	11.8
Croaker/lb.	0.5	12.5	23.1	10.8	10.0	5.5	1.6	3.1	10.4	6.6
Mixed/lb.	2.4	36.0	43.3	15.0	14.5	15.2	35.8	33.2	17.7	17.2
Industrial fish/lb.	1.1	38.9	14.9	28.3	29.2	51.9	27.9	52.2	27.7	46.1
Invertebrates/lb.	88.7	11.2	9.8	36.2	.2.2	13.2	19.5	9.6	4.5	18.3
Shrimp/lb.	(0.1)	(2.3)	(0.0)	(0.8)	(0.2)	(1.2)	(0.5)	(0.3)	(0.2)	(1.0)

[1]From Rathjen et. al 1969.

species (flyingfish, squids, etc.) which had been attracted to the vessel's lights. The numbers of dolphin were seen to increase daily until at the end of the drift, it was estimated that there was one dolphin per square yard of sea surface within sight of the vessel.

Since the experience gained during the placing of the four anchored fish attraction rafts off Barbados in 1968 pointed up the problems of anchored devices close to land, another device was sought. Based on the experience of *Discoverer*, a drift fishing cruise by a Project vessel was conceived.

Calamar Cruise 70-5

In May of 1970, *Calamar* conducted experimental drift fishing during cruise 70-5 (29 April - 18 May 1970). The objects of the cruise were:

1. To determine if a drifting vessel could attract a marine colony containing commercially desirable species in commercially significant quantities.
2. To gauge the effect of continued drift on the cumulative size of any colony attracted.
3. To test various fishing methods on any fish attracted.

It was proposed that the hull of *Calamar* should be the fish attractor. Lights were rigged overside at night to increase attraction. After taking on live bait in Man-of-War Bay, Tobago, *Calamar* proceeded to a point about 200 miles southeast of Barbados. This position was calculated to allow the vessel to drift close to Barbados for whatever effect the land might offer in concentrating fish. The vessel was tethered to two 27-foot diameter personnel parachute sea anchors. These reduced wind drift by holding the vessel into the wind and sea and also provided for a smoother condition aboard. After transiting about 360 track miles in 314 hours, the drift was terminated some 20 miles west of St. Lucia (Fig. 3). The average speed throughout the drift was about 1.1 knots, but during some days over 35 miles were covered in 24 hours with speeds up to 2.5 knots observed over shorter periods.

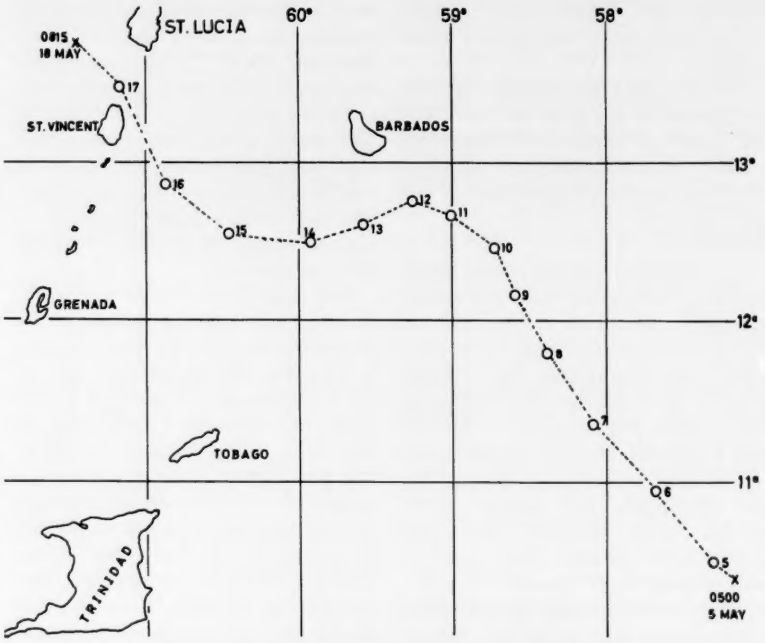

Figure 3.—Drift track—*Calamar* Cruise 70-5. Circles indicate noon position of vessel; numbers are day of month.

For fishing equipment, the vessel carried handlines, tuna pole-and-line rigs, sport rods and reels, an 18 foot outboard-powered dory rigged for trolling, 5½-inch and 1¾-inch mesh gillnets, 10 baskets of tuna longline, and dip nets. Live and frozen fish bait were also carried.

A summary of the catch by drifting day is presented in Table 5. Fourwing flyingfish, *Hirundicthys affinis*, was the first species attracted to the vessel. A few were taken on the first drifting day. After 200 pounds were caught using handlines, dip nets, and gill nets, no additional flyingfish, except those dipped for live bait, were taken in order to retain any attractive force a school of this species may have exerted on the larger pelagic fishes. Dolphin fish were taken from the deck of *Calamar* using handlines, rod and reel, and pole-and-line, all using live fish for bait. Once a dolphin was attracted to the boat, it appeared to remain in the vicinity until finally caught, even though it might have been previously hooked and lost. For this reason, it is felt that a very high proportion (90+ percent) of the fish attracted to the vessel were eventually caught. Wahoo were shy and, even though they were observed jumping in the vicinity of the vessel, none were caught until the skiff was placed overside to troll around the vessel. (At the termination of the drift, seven wahoo were taken in the immediate area within 15 minutes by trolling from the *Calamar*.) From this first day of drifting, the vessel appeared to acquire

Table 4.—List of anchored fish attraction structures.

Date	Structure	Location	Longevity	Results
12 Feb. 68	Bamboo bundle	Kleijn Curacao, N.A.	5 days (lost)	Nil
15 Feb. 68		Kralendijk, Bonaire, N.A.	2 days (lost)	Nil
1 Apr. 68	Bamboo covered wood frames	London Shallows, Barbados	14 days (lost)	Nil
1 Apr. 68			1-2 mo. (lost)	Nil
1 Apr. 68			(lost)	4 dolphins - 80 lbs.
1 Apr. 68			(lost)	Nil
1 Aug. 69	Bamboo bundle	N. Anguilla Bank	7 days (set adrift)	Nil
10 Feb. 71		270 fm. S. of Barbados	6 days (lost)	1 dolphin - 12 lbs.
14 Apr. 71		190 fm. N. of Barbados	5 days (lost)	Nil
24 May 71	Floating fish pot		1 day (sank)	Nil
28 May 71		Middle Shallows, Barbados	2 days (terminated)	fish reported
19 June 71		N.E. Anguilla Bank	6 days (terminated)	3 barracuda

Table 5.—Daily fish catch of *Calamar* Cruise 70-5 while drifting.
0 = NUMBERS (000) = POUNDS

Fish Species	May 5	6	7	8	9	10	11	12	13	14	15	16	17	18	Totals
Flying-fish	-(200)														-(200.0)
Dolphin			3	25	1	4	1	5	8	12	6		13	1	79
			(56)	(468)	(16)	(93)	(33.5)	(106)	(136)	(232.5)	(117.5)	—	(239)	(20)	(1,517.5)
Wahoo					1	2				4	2			7	16
					(21)	(29)				(54.5)	(21)			(108)	(233.5)
Yellowfin tuna				1		2	42	19	3	8	9		28	1	[1]113
				(135)		(12)	(349)	(130)	(35)	(71)	(63.5)		(221)	(11)	(1,027.5)
Skipjack tuna							8	1			1		1		11
							(40)	(4.5)			(4.5)		(4.5)		(53.5)
Bigeye tuna	1														1
	(115)														(115.0)
Rainbow runner					3	2	6	3	2	6		1	11	2	36
					(14)	(8)	(54)	(21)	(14.5)	(56)		(8.5)	(64)	(16)	(256.0)
Trigger-fish												-(200)			-(200.0)
Sharks	1	1		1	1			1	1	2	1	1			10
	(25)	(30)		(75)	(30)			(86)	(35)	(52)	(65)	(22)			(420.0)
Total	(340)	(30)	(56)	(678)	(81)	(142)	(476.5)	(347.5)	(220.5)	(466.0)	(271.5)	(230.5)	(528.5)	(155.0)	(4,023.0)

[1]Most of this total had previously been reported (Caribbean Fishery Development Project Cruise Report No. 28) as blackfin tuna (*Thunnus atlanticus*), but positive identification of identical fish taken from the same general geographic area and in association with the same species complex during *Calamar* Cruise 71-7 have prompted this reidentification.

a population of tuna which increased and decreased for no apparent reason throughout the 2 weeks. Small yellowfin tuna, *Thunnus albacares*, were almost always present, while skipjack tuna, *Katsuwonus pelamis*, was often seen. All of these species plus one bigeye tuna, *Thunnus obesus*, were taken on either handlines or rod and reel from the vessel. The rainbow runner, *Elagatis bipinnulata*, was very much in evidence under the vessel, but very difficult to catch and then only by heavy chumming with live bait. A few sharks were taken, but the vessel did not appear to attract sharks from long distances. The ocean triggerfish, *Canthidermis sufflamen*, was much in evidence and could be dip netted or caught on handlines. A few squids were observed and taken on jigs. Many small (2-3 inch) green jacks, *Caranx caballus*, were observed around the vessel along with other unidentified small species. The hydrographic conditions observed during the cruise were nearly stable, with surface temperatures between 27.8° and 28.5°C and thermocline depths between 85 and 100 meters.

The catch results of *Calamar* Cruise 70-5 and observations made during the voyage confirmed that a marine colony was established around the vessel during the period of the drift. The catch results do not confirm commercial quantities taken; however, a major hindrance to more thorough fishing was the inability of the vessel to utilize all of the methods available to her without seriously disturbing the established colony. Although trolling was seen to be somewhat successful, it could only be done by the skiff during the best of weather. Gill nets were set and recovered twice with extreme difficulty, while longlines could not be utilized at all.

Calamar Cruise 70-6

An opportunity to remedy the conditions observed during cruise 70-5 was presented on cruise 70-6 (26 June - 5 July) when *Calamar* rendezvoused with the papyrus sailing raft *Ra II*. This craft had sailed before the wind from the Moroccan coast of Africa before she was met by *Calamar* about 800 miles east-northeast of Barbados. Previous radio contact had indicated that a considerable body of fish, including dolphin, shark, flyingfish, skipjack tuna, etc., were being seen regularly around the raft. However, in 10 hours of fishing effort, close by the raft, using trolling lines, handlines, and one gill net set, only one small dolphin and 10 flyingfish were caught.

Calamar Cruise 71-7

Since the original objectives set forth for cruise 70-5 still had only partially been met, *Calamar* Cruise 71-7 (19 May - 5 June 1971) was conceived and carried out. In cruise 71-7, the fishing vessel placed, tracked, and monitor-fished a number of attraction structures. This allowed the vessel to use any fishing gear deemed suitable anywhere in the vicinity of structures or the surrounding area with the added advantage of more than one attraction device.

Although the cruise had been scheduled for 17 days, mechanical troubles causing the ship to return to port split the cruise into two almost equal periods. This allowed the experience gained during the first part to be applied to the work conducted during the latter part. During the first half of the cruise, three fish attraction structures consisting of a flag buoy with a radar reflector array, linked to slightly submerged West Indian "Z" fish pots (10 × 4 × 3 feet), were attached to a 24-foot diameter parachute-type sea anchor (Fig. 4a). The three structures were placed about two miles apart at the points of an equilateral triangle about 160 miles east-southeast of Barbados (Fig. 5). This location allowed for an expected drift path close to, but not intercepting, the northern Leeward Islands. With the sea anchors at about 10-15 fathoms deep, the structures did not drift appreciably. After 4 days, two of the three parachute anchors were replaced with "D" style fish pots (6 × 4 × 4 feet) which caused the structures to immediately begin to drift northward. The third structure remained behind and was eventually lost.

Keeping station on the structures was found to be difficult. The first three rafts were fitted with an array of radar reflectors which proved to be of

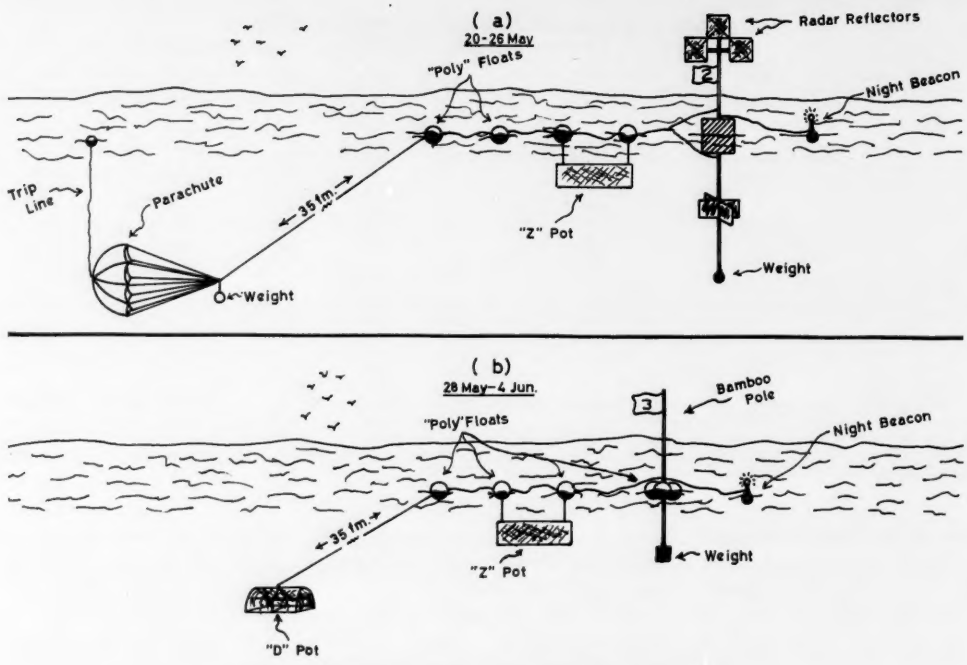

Figure 4.—Fish attraction structures used during *Calamar* Cruise 71-7.

no value as such, because the ship's radar was found to be weak and ineffective. The reflectors did provide good visibility against the horizon however, and were used to visually locate each structure. At night, the ship used two parachutes to anchor herself near the most westerly structure, to which a light beacon had been affixed. Bearings on this light were taken hourly from the ship and after sunrise, when the ship's sea anchor had been hauled, it was possible to return to the leading structure, which provided a point of departure from which the ship might locate the remaining structures.

During the second half of the cruise, six identical structures with "D" pot sea anchors and no radar reflectors (Fig. 4b) were placed on an east-west line at 1.5-mile intervals, approximately 30 miles east of Barbados. Based on the experience of the first half of the cruise, a northerly drift was expected; however, after 7 days all the structures had drifted westerly around the south end of Barbados and generally northwesterly until they intercepted St. Lucia (Fig. 1). One structure lost its sea anchor and was taken aboard after 5 days' drifting. The remaining five structures had spread in a rough line, 25 miles long, which split in passing St. Lucia, causing the loss of three more structures on the last day of the drift.

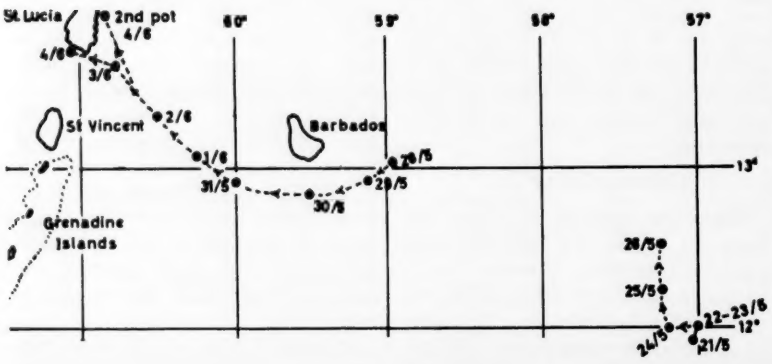

Figure 5.—Drift track—*Calamar* Cruise 71-7. Solid circles represent 0500 daily position of structures. Numbers are day/month.

Fishing techniques varied and were fitted to the conditions and type of fish in evidence. The usual technique was to monitor a structure by trolling a feather jig close to it and then using handlines if any fish were taken trolling. Handlines were fished, either drifting with live flyingfish bait (dolphin and wahoo) or trolling at slow speed with a whole or piece of dead flyingfish for bait (wahoo and rainbow runner). Sharks were taken with handlines only while drifting. All tunas were taken by trolling artificial lures. Two gill net sets, one of two shackles of 1¾-inch mesh and one immediately thereafter of three shackles, netted 237 flyingfish weighing 78 pounds. Thereafter, flyingfish were either dip-netted

Table 6.—Daily fish catch of *Calamar* cruise 71-7.
0 = NUMBERS (000) = POUNDS

Fish species	May 21	22	23	24	25	26	29	30	31		June 1	2	3	4	Totals
Dolphin	10	—	16	1	1	3	12	7	1			14	5	4	74
	(167.5)		(265.5)	(25.0)	(25.0)	(45.0)	(259.0)	(158.0)	(7.0)			(215.0)	(102.0)	(64.0)	(1,333.0)
Wahoo	6	—		2		3						2	16		29
	(87.5)			(22.5)		(46.5)						(23.5)	(150.0)		(330.0)
Rainbow		1			3	4	8	3	1						20
runner		(10.0)			(22.0)	(36.0)	(79.0)	(26.5)	(12.0)						(185.0)
Yellowfin	1	4		46	53	21		10	7					8	150
tuna	(5.0)	(18.0)		(217.0)	(264.0)	(96.0)		(53.0)	(38.0)					(43.5)	(734.5)
Skipjack		7		9	29	4		3					3		55
tuna		(24.5)		(38.0)	(115.0)	(15.5)		(16.5)					(19.0)		(228.5)
Whitetip		3	1			4	2		2						12
shark		(101.0)	(65.0)			(105.0)	(128.0)		(61.0)						(460.0)
Silk shark			1						1			1			3
			(18.0)						(21.0)			(18.0)			(57.0)
Flying-	237														237
fish	(78.0)														(78.0)
Ocean trigger-	7					3									10
fish	(21.0)					(7.5)									(28.5)
Totals	(359.0)	(153.5)	(348.5)	(302.5)	(426.0)	(351.5)	(466.0)	(254.0)	(139.0)			(256.5)	(314.5)	(64.0)	(3,435)

No fish

or caught by hook and line for bait only, as it was felt that they could be an attraction on their own to larger fish when they were schooled in the vicinity of the structures.

Ocean triggerfish were removed from the near surface "Z" fish pots. The "D" pot sea anchors caught nothing. Once a shackle of 5-inch gill net 30 fathoms long was set in the midst of a school of jumping skipjack tuna, but none was caught. While drifting overnight, the vessel placed lights above and beneath the surface to attract fish. Little success was achieved.

The overall fish catch results are given in Table 6. These totals are not divided by structure fished, as it was apparent that fish were attracted and held to a structure purely through chance encounter and not because of any greater attractiveness by one structure over another. As in the previous work of this kind, dolphin fish provided the greater poundage of fish taken. Their association with the structures was marked and acute. To an only slightly lesser degree wahoos were attracted and held. The two shark species (*Carcharhinus longimanus* and *C. falciformis*) were obviously attracted and held and were in close association with rainbow runner. Flyingfish and ocean triggerfish were the first species to associate with the structures, with flyingfish dispersing immediately after the larger pelagic predators came along. The association between the structures and tunas was not a definite one. About 10 percent of the yellowfin tuna taken were caught in their immediate vicinity, but the remainder, plus all the skipjack tuna, were caught trolling, sometimes close by and other times up to 3-4 miles away from the structures.

Flyingfish attracted to the structures were often in a spawning condition so that upon final recovery, the "Z" pot and even the connection lines and floats making up the rest of the structure were covered with newly spawned eggs.

The results of this cruise did not indicate any real potential for this fishing method. Fish were attracted to the structures, probably in greater total numbers than to the ship alone. However, the difficulty in tracking each structure together with (and somewhat caused by) the spreading out and loss of the structures as time passed, with consequent lower catches, outweighed this fact.

Summary and Conclusions

The objectives set forth at the beginning of cruise 70-5 were met as follows:

1. The drifting objects (as opposed to the meager results shown by anchored objects), either boats or attraction structures, did attract and hold pelagic fish aggregations.
2. The size of the aggregation attracted did increase in size and species complexity with increased time in the water.
3. The degree of attraction was species dependent. The most strongly attracted species were dolphin fish, flyingfish, ocean triggerfish, and sharks. Next were wahoo and rainbow runner, while the tunas appeared to be least attracted.
4. The attraction of any fish appears to be due to random encounter with the drifting object and while the chances of such encounter may be slightly increased by an increase in the size of the surrounding fish aggregation, the removal of some fish does not seem to affect the overall attractiveness of the object.

From the results obtained, it must be concluded that no significant commercial potential was demonstrated by the project's experimental efforts in fish attraction.

SCALLOPS

At fishing station 491 (20 July) of *Calamar* cruise 68-7 (10-26 July 1968), two scallops (*Pecten* sp.) were trawled from about 40 fathoms, 10 miles northwest of Los Testigos Islands, Venezuela. The results of this and subsequent tows of the roller rigged 52 × 76 foot snapper trawl where scallops were caught are given in Table 7.

Since the footrope of a roller rigged trawl fishes relatively high over the bottom, it is not considered a good sampling tool for scallops. This showing of scallops, using a roller rigged trawl, was highly encouraging. A 6 foot tumbler-type scallop dredge was obtained and used during *Calamar* cruise 78-12 (28 October - 4 November 1968). The results are given in Table 8.

Although preliminary findings with unsuitable gear were encouraging, the results of scallop dredging in the area around Margarita Island and Los Testigos were unsatisfactory in terms of their commercial potential.

Table 7.—Scallop catch using roller rigged snapper trawl - *Calamar* Cruise 68-7.

Station	Date	Location (Venezuela)	Depth (fm)	Amount	Remarks
491	7/20/68	10 mi. NW Los Testigos Is.	39-40	2	
493	7/20/68	28 mi. WNW Los Testigos Is.	33	20	
494	7/21/68	20 mi. N Margarita Is.	28-33	20	
496	7/21/68	17 mi. N Margarita Is.	34-36	1½ bucket	3½-4 inch diameter
497	7/21/68	10 mi. N Margarita Is.	24-32	1 bushel	65 meats/ lb.
507	7/24/68	8 mi. W Los Testigos Is.		30	

GILL NETTING

Gill net fishing was accomplished under a variety of circumstances during the Project life. Surface-floating gill netting for medium and small sized pelagic species plus anchored bottom gill netting for demersal species all received some degree of attention. On two occasions, attempts were made to encircle surface pelagic schools with a gill net.

A total of 83 gill net sets during 10 cruises by all three project vessels yielded 2,702 pounds. Forty-three surface nets of 1½ inch monofilament net (usually one shackle of 15 × 5 fathoms) yielded 590 pounds of flyingfish (*Exocetidae*) and 515 pounds of mixed clupeid fishes. Thirty-one sets of 4¾ inch, 5 inch, or 5½ inch surface sets for medium sized pelagic species caught 1,167 pounds. Nine anchored sets of bottom net yielded 428 pounds. The encircling surface sets caught one 2-pound shark.

During *Alcyon* Cruise 67-9, small mesh surface gill netting in Kingston (Jamaica) harbor produced 515 pounds of clupeid bait fish during four nights' operations. Nylon monofilament nets for tunas and other medium sized pelagic species were fished on the banks south of Jamaica. During *Alcyon* Cruise 67-10 four sets of one 5-fathom shackle of 5 inch or 5½ inch gill net off Morant Cays produced no fish. One drifting set of 5-inch mesh caught two horse-eye jacks (*Caranx latus*) and several sharks. One encircling set around a surface school of skipjack tuna yielded nothing.

On *Alcyon* Cruises 69-9 and 10, several sets of 5-inch and 5½-inch mesh gill net on banks south of Jamaica yielded only 45 pounds of horse-eye jacks and several sharpnose sharks (*Rhizoprionodon porosus*).

Calamar Cruises 70-5 and 71-7 were devoted to fish attraction and three sets of 1½-inch mesh gill net caught 328 pounds of flyingfish. Two sets of 5½-inch mesh net, one in the midst of a school of jumping skipjack tuna, yielded only two ocean triggerfish (*Canthidermis sufflamen*).

During survey operations in the Netherlands Antilles (*Fregata* Cruises 68-1 and 68-2) 24 net hours of night time 1½ inch Barbados hung flyingfish gill net effort yielded 3.83 fish per hour, while 72.5 net hours of daytime effort produced 7.14 fish per net hour. The total catch for all effort was 251 pounds.

Fregata's Cruise 68-3 produced 35 flyingfish in eight daytime sets of 1½-inch mesh net from the waters around Barbados. Two sets of 5-inch mesh net in the same area yielded one 12 pound rainbow runner (*Elagatis bipinnulata*).

During *Fregata*'s Cruise 68-7 experimental gill netting was conducted off the coasts of Trinidad and Tobago. A total of 22 gill net sets was made, of which 12 were drift sets, 9 were anchored sets, and 1 was an encircling set. The drift sets were made along the southwest coast of Trinidad around the Serpent's Mouth. The objectives of the drift set operations were to test the relative effectiveness of monofilament and multifilament nylon gill nets during the day and night. In all but one drift set, the gear was comprised of two 60-fathom shackles of 4¾-inch monofilament gill nets strung alternately between three 60-fathom shackles of 4-inch multifilament gill nets. Four day drift sets, averaging approximately 2 hours soak, produced one Spanish mackerel (*Scomberomorus maculatus*) and one leatherjacket (*Oligoplites saurus*). The remaining eight drift net sets made at night were much more productive. These night sets were soaked for approximately 4 hours. A total of 588 fish was taken of which 329 were leatherjackets, 96 were Spanish mackerel, 95 were catfish (mostly *Arius* sp.), 19 were unidentified sharks, and 41 were miscellaneous species. The multifilament net was more effective than the monofilament net (Table 9); the former caught 17.69 fish, whereas the latter caught only 12.07 fish per shackle per set.

Anchored gill nets were fished on nine occasions during this cruise, six times off the north coast of Trinidad and three times off Tobago (Table 10). The nets used were 65 fathom (fished eight times) and 125 fathom (fished once), 4 inch multifilament gill nets. Soaking time of the six sets off Trinidad averaged slightly over 9 hours. These sets produced a total of 232 fish weighing 417 pounds. The bulk of the catch was comprised of 84 (196 pounds) Spanish mackerel and 95 (139 pounds) sharks. Anchored gill netting off Tobago was much less productive than off the north coast of Trinidad. Three sets averaging 12½ hours soaking time off Tobago produced only seven fish weighing 11 pounds.

An encircling set attempted off the north coast of Trinidad with a 125

Table 8.—Scallop catch using 6 foot tumbler dredge.

Station	Date	Location (Venezuela)	Depth (fm)	Catch
603	10/29/68	30 mi. NE Margarita Is.	33	1
604	10/29/68	10 mi. N Margarita Is.	33	1
605	10/29/68	8 mi. N Margarita Is.	33	nil
606	10/30/68	9 mi. NW Margarita Is.	31	42
607	10/30/68	9 mi. N Margarita Is.	26	33
608	10/30/68	8 mi. W Margarita Is.	26	46
609	10/30/68	10 mi. N Margarita Is.	26	nil
610	10/30/68	9 mi. NW Margarita Is.	27.5	49
611	10/30/68	9 mi. NW Margarita Is.	24.5	3
612	10/30/68	10 mi. N Margarita Is.	30	3
613	10/30/68	11 mi. N Margarita Is.	30	4
614	10/30/68	10 mi. N Margarita Is.	26	6
615	10/30/68	8.5 mi. N Margarita Is.	19	3
616	10/31/68	25 mi. ENE Margarita Is.	19	nil
617	10/31/68	7 mi. W Los Testigos Is.	26	nil
618	10/31/68	4 mi. N Los Testigos Is.	34	nil
619	10/31/68	24 mi. SE Los Testigos Is.	36	nil

Table 9.—Drift gill net fishing catches.

	Day fishing			Night fishing		
	Multi	Mono	Total	Multi	Mono	Total
No. of sets	4	4	4	8	8	8
No. of shackles	12	8	20	23	15	38
Soak time/shackle	2h05m	2h05m	2h05m	3h51m	3h51m	3h51m
	No.	No.	No.	No.	No.	No.(lbs)[1]
Leatherjacket		1	1	196	133	329(800)
Spanish mackerel	1		1	81	15	96(216)
Catfish				80	15	95(—)
Shark				12	7	19(—)
Miscellaneous				38	11	49(—)
Total catch	1	1	2	407	181	588(1,016)

[1]Estimated weight.

Table 10.—Anchored gill net fishing catches.

	Trinidad	Tobago
No. of sets	6	3
No. of shackles	6	3
Soak time/shackle	9h23m	12h28m
	No.(lbs)	No.(lbs)
Spanish mackerel	74(196)	4(8)
Jacks	10(20)	3(3)
Sharks	95(139)	-(—)
Miscellaneous	53(62)	-(—)
Total catch	232(417)	7(11)

fathom, 4 inch multifilament gill net caught one small shark.

Thus, with the exception of night sets in the vicinity of Trinidad and Tobago, the gill net efforts put forth by the project were not successful. It is concluded that the method does not lend itself well to circumstances in the West Indies and is not generally recommended.

CONCLUSIONS

Deepwater bottom longlining did not show separate commercial potential and is recommended only as an adjunct to deepwater snapper line or pot fishing. Incidental trawling for shark bait was successful for catching bait and also for catching small quantities of salable food fish.

Fish attraction showed no commercial potential, and exploratory scallop dragging displayed no commercial potential. Even with extensive geographic coverage and wide range of setting techniques, gill netting did not display extensive commercial potential throughout the project region.

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